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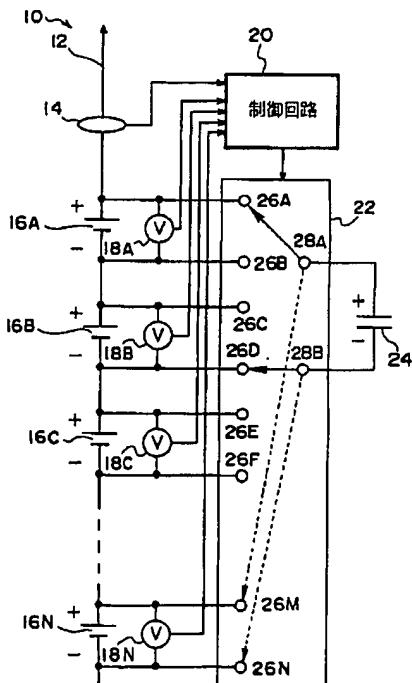
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(54)【発明の名称】 蓄電装置

(57)【要約】

【課題】 直列に接続された複数の蓄電手段の均等化を正確かつ適切に行う。

【解決手段】 直列に接続された複数のバッテリセル16の各々の電圧を、回路12に電流が流れていらないときに検出し、このとき検出された電圧に基いて電荷持ち出しセルと電荷受取りセルの決定、均等化動作を行う時間の算出を行い、各バッテリセルの充電状態均等化動作をスケジュール化する。



AN

【特許請求の範囲】

【請求項1】 直列に接続された複数の蓄電手段と、前記蓄電手段の各々の電圧を検出する電圧検出手段と、前記蓄電手段から電流が流れているか否かを検知する検知手段と、前記検知手段により電流が流れないと検知されたときの前記電圧検出手段により検出された前記蓄電手段の各々の電圧に基いて、前記複数の蓄電手段の蓄電量を均等化する均等化手段と、を備えた蓄電装置。

【請求項2】 前記均等化手段は、前記蓄電手段の各々と接続可能な蓄電器と、少なくとも1つの前記蓄電手段から前記蓄電器を介して少なくとも1つの他の前記蓄電手段に電荷を移動させる移動手段と、前記蓄電手段の各々の電圧に基いて、前記複数の蓄電手段の蓄電量が均等になるための、電荷を放出する放出蓄電手段および放出された電荷を受取る受取り蓄電手段と、該放出蓄電手段から該受取り蓄電手段への電荷移動量とを決定する決定手段と、前記決定手段により決定された電荷移動量が前記放出蓄電手段から前記受取り蓄電手段へ移動するように前記移動手段を制御する制御手段と、を備えた請求項1記載の蓄電装置。

【請求項3】 前記決定手段は、前記放出蓄電手段の数をN、前記放出蓄電手段の第n番目の電圧をV_{ns}、均等化後の前記放出蓄電手段の第n番目の目標電圧をV_{n(t)}、前記受取り蓄電手段の第m番目の電圧をV_{rm}、均等化後の前記受取り蓄電手段の第m番目の目標電圧をV_{rm(t)}、前記蓄電手段の電気容量をC_b、前記蓄電器の電気容量をC_c、前記蓄電器を介して前記放出蓄電手段から前記受取り蓄電手段に電荷の移動が行われる周期をT_i、前記放出蓄電手段から前記蓄電器へ電荷を移動させる際の電荷損失分を考慮した係数を η 、前記蓄電器から前記受取り蓄電手段へ電荷を移動させる際の電荷損失分を考慮した係数を λ 、として次の2式から算出した時間t_n、t_mの内にいずれか短い時間の間前記移動手段により電荷の移動を行うことにより移動する電荷を前記電荷移動量として決定することを特徴とする請求項2記載の蓄電装置。

【数1】

$$t_n = \frac{N(V_{ns} - V_{n(t)})}{\alpha(\sum_{n=1}^N V_{ns} - \sum_{m=1}^M V_{rm})}$$

$$t_m = \frac{M(V_{rm(t)} - V_{rm})}{\eta \cdot \alpha(\sum_{n=1}^N V_{ns} - \sum_{m=1}^M V_{rm})}$$

ただし、

【数2】

$$\alpha = \frac{\lambda \cdot C_c}{C_b \cdot T_i}$$

【請求項4】 前記均等化手段は、

前記蓄電手段から電気量を放電する放電手段と、前記蓄電手段の各々の電圧に基いて、前記複数の蓄電手段の蓄電量が均等になるための電気量を放電する放電蓄電手段と、該放電蓄電手段から放電する電荷放電量とを決定する決定手段と、

前記決定手段により決定された電荷放電量が前記放電蓄電手段から放電されるように前記放電手段を制御する制御手段と、を備えた請求項1記載の蓄電装置。

【請求項5】 前記放電手段は、前記蓄電手段からの電荷を消費するための、抵抗値が、前記蓄電手段内部の抵抗値の100倍以上の抵抗値を備えたことを特徴とする請求項4記載の蓄電装置。

【請求項6】 前記決定手段は、均等化後の目標電圧をV_r、前記蓄電手段の電気容量をC_b、前記蓄電手段の電圧をV_s、前記抵抗器の抵抗値をR_{BP}、として次の2式から算出した時間t_{r1}またはt_{r2}の内にいずれか一方の時間の間放電する電気量を前記放電手段で放電する電荷放電量として決定することを特徴とする請求項5記載の蓄電装置。

【数3】

$$t_{r1} = -\frac{1}{\alpha} \ln \left(\frac{V_{br}}{V_s} \right)$$

【数4】

$$t_{r2} = \frac{1}{\alpha} \left(1 - \frac{V_{br}}{V_s} \right)$$

30 ただし、 $\alpha = 1 / (C_b \cdot R_{BP})$

【発明の詳細な説明】

【0001】

【発明の属する技術分野】 本発明は、蓄電装置に係り、より詳細には複数の蓄電池を直列に接続した蓄電装置の各蓄電池間の充電状態を均等化することの可能な蓄電装置に関する。

【0002】

【従来の技術】 近年技術開発が進められている電気自動車の電源としては、複数の蓄電池を直列に接続した蓄電装置（組電池）が使用されている。このように、多数の蓄電池を直列に接続した蓄電装置の場合、出力は最も低い電圧の電池に依存するため、各電池の充電状態にはばらつきがあると各電池を均等に使用することができず、各電池の能力を最大限に発揮することができないといった不都合がある。

【0003】 そこで、従来より各電池の充電状態を均一にすべく種々の電圧均衡化回路が提案されている。例えば、特開平10-322925号公報に開示されているものでは、単電池毎に放電回路を設け、各単電池の開放電圧を検出し、この開放電圧に基いて放電回路により各

単電池の電気量を放電して各単電池の充電率が均一になるように調整する。また、特開平11-103534号公報に開示されているものでは、各単電池に並列接続可能な蓄電器を設け、各単電池の開放電圧を検出した後に蓄電器に充電する電池と蓄電器から放電を受ける電池を選択する。そして、まず充電する側の電池と蓄電器を接続して蓄電器に充電を行い、次に放電を受ける側の電池と蓄電器を接続して該電池の充電を行う。この処理サイクルを所定回数（指定サイクル数）行うことによって各単電池間の充電率を調整していた。

【0004】

【発明が解決しようとする課題】しかしながら、前述の特開平10-322925号公報に開示されている先行技術では、放電電気量は放電回路に電流を流す時間に比例することを前提にしているため、放電による電池電圧の低下とともに放電回路に流れる電流も低下することが考慮されていない。したがって、放電すべき電気量に応じた正確な時間分だけ電池から電気量を放電することができなかった。また、放電回路の抵抗値と電池内部の抵抗値の関係について考慮されていないため、放電回路の抵抗値と電池内部の抵抗値との比が小さい場合に、主回路を電流が流れた場合には（以下「主電流」という）、主電流が流れていなかった場合と比較して放電回路に大量の電流が流れ、目標とした放電電気量よりも多量の電気量を放電するという不都合があった。

【0005】また、特開平11-103534号公報に開示されている先行技術では、蓄電器に充電する電池と蓄電器から放電を受ける電池とを選択するための各電池電圧を、主電流が流れているか否かにかかわらず電圧均等化処理の指定サイクル数毎に検出している。主電流が流れている状態と流れていらない状態とでは電池電圧が変動するため各電池の正確な開放電圧が測定できず、蓄電器に充電する電池と蓄電器から放電を受ける電池とを正確に選択することができなかった。そこで、主電流が流れていらないときに電圧を測定して電圧均等化処理をすることも考えられるが、電圧均等化処理の指定サイクル数は比較的短く、そのため頻繁に電池電圧を検出して蓄電器に充電する電池と蓄電器から放電を受ける電池とを選択しなければならず、実際には長時間主電流が流れていないと、すなわち車両停止時に電圧均等化処理することになる。これでは電圧均等化処理が車両停止時にしか行えないことになり、電圧均等化処理の効果を十分に発揮することができなかった。

【0006】本発明は、上記事実に鑑みてなされたものであり、各蓄電手段の電圧均等化処理をより正確に行うことの可能な蓄電装置を提供することを目的とする

【0007】

【課題を解決するための手段】上記目的を達成するため、本発明に係る蓄電装置は、直列に接続された複数の蓄電手段と、前記蓄電手段の各々の電圧を検出する電圧

検出手段と、前記蓄電手段から電流が流れているか否かを検知する検知手段と、前記検知手段により電流が流れないと検知されたときの前記電圧検出手段により検出された前記蓄電手段の各々の電圧に基いて、前記複数の蓄電手段の蓄電量を均等化する均等化手段と、を含んで構成される。

【0008】本発明に依れば、前記蓄電手段から電流が流れないと検出された前記蓄電手段の各々の電圧、すなわち、前記蓄電手段がその内部抵抗等により影響を受けていない状態での正確な電圧に基いて前記蓄電手段を均等化するので、正確に適切な均等化を行うことができる。

【0009】ここで均等化とは、前記蓄電手段の充電状態のばらつきを減少させることをいい、より好ましくは前記蓄電手段の充電状態が均一になることをいう。

【0010】本発明は請求項2のように、前記均等化手段は、前記蓄電手段の各々と接続可能な蓄電器と、少なくとも1つの前記蓄電手段から前記蓄電器を介して少なくとも1つの他の前記蓄電手段に電荷を移動させる移動手段と、前記蓄電手段の各々の電圧に基いて、前記複数の蓄電手段の蓄電量が均等になるための、電荷を放出する放出蓄電手段および放出された電荷を受取る受取り蓄電手段と、該放出蓄電手段から該受取り蓄電手段への電荷移動量とを決定する決定手段と、前記決定手段により決定された電荷移動量が前記放出蓄電手段から前記受取り蓄電手段へ移動するように前記移動手段を制御する制御手段と、を備えて構成することもできる。

【0011】本発明に依れば、前記決定手段により決定された電荷移動量に基いて前記蓄電手段間の電荷を移動させて、均等化処理のスケジュール化が図られ、何度も前記蓄電手段の電圧を検出する必要がなくなる。

【0012】また、本発明は請求項3のように、前記決定手段は、前記放出蓄電手段の数をN、前記放出蓄電手段の第n番目の電圧をV_ns、均等化後の前記放出蓄電手段の第n番目の目標電圧をV_n(t)、前記受取り蓄電手段の第m番目の電圧をV_ms、均等化後の前記受取り蓄電手段の第m番目の目標電圧をV_m(t)、前記蓄電手段の電気容量をC_b、前記蓄電器の電気容量をC_c、前記蓄電器を介して前記放出蓄電手段から前記受取り蓄電手段に電荷の移動が行われる周期をT₁、前記放出蓄電手段から前記蓄電器へ電荷を移動させる際の電荷損失分を考慮した係数をη、前記蓄電器から前記受取り蓄電手段へ電荷を移動させる際の電荷損失分を考慮した係数をλ、として次の2式から算出した時間t_n、t_mの内のいざれか短い時間の間前記移動手段により電荷の移動を行うことにより移動する電荷を前記電荷移動量として決定することを特徴とすることもできる。

【0013】

【数5】

$$t_n = \frac{N(V_{ns} - V_{n(t)})}{\alpha(\sum_{n=1}^N V_{ns} - \sum_{m=1}^M V_{rms})}$$

$$t_m = \frac{M(V_{rm(t)} - V_{rms})}{\eta \cdot \alpha(\sum_{n=1}^N V_{ns} - \sum_{m=1}^M V_{rms})}$$

【0014】ただし、

【0015】

【数6】

$$\alpha = \frac{\lambda \cdot C_c}{C_b \cdot T_I}$$

【0016】本発明に依れば、前記の式により算出した時間 t_n 、 t_m の内のいずれか短い時間の間前記移動手段により電荷の移動を行うことにより移動する電荷を前記電荷移動量として決定するので、より正確に電気量を移動することができる。

【0017】また、本発明は請求項4のように、前記均等化手段は、前記蓄電手段から電気量を放電する放電手段と、前記蓄電手段の各々の電圧に基いて、前記複数の蓄電手段の蓄電量が均等になるための電気量を放電する放電蓄電手段と、該放電蓄電手段から放電する電荷放電量と、を決定する決定手段と、前記決定手段により決定された電気量が前記放電蓄電手段から放電されるように前記放電手段を制御する制御手段と、を備えて構成することもできる。

【0018】本発明に依れば、前記決定手段により決定した電気量に基いて前記放電蓄電手段から電気量を放電するので、均等化処理のスケジュール化が図られ、何度も前記蓄電手段の電圧を検出する必要がなくなる。

【0019】また、本発明は請求項5のように、前記放電手段は、前記蓄電手段からの電荷を消費するための抵抗値が、前記蓄電手段内部の抵抗値の100倍以上の抵抗値を備えたことを特徴とすることもできる。本発明に依れば、前記蓄電手段からの電荷を消費するための抵抗値が、前記蓄電手段内部の抵抗値の100倍以上であるので、前記蓄電手段に電流が流れた場合でも放電手段内に流れ込む電流を少量に抑えることができ、前記蓄電手段に電流が流れた場合でも均等化処理を正確に行うことができる。

【0020】さらに、請求項6のように、前記決定手段は、均等化後の目標電圧を V_r 、前記蓄電手段の電気容量を C_b 、前記蓄電手段の電圧を V_s 、前記抵抗器の抵抗値を R_{RP} 、として次の2式から算出した時間 t_{r1} または t_{r2} の内のいずれか一方の時間の間放電する電荷放電量を前記放電蓄電手段から放電する電荷放電量として決定することを特徴とすることもできる。

【0021】

【数7】

$$t_{r1} = -\frac{1}{\alpha} \ln \left(\frac{V_{br}}{V_s} \right)$$

【0022】

【数8】

$$t_{r2} = \frac{1}{\alpha} \left(1 - \frac{V_{br}}{V_s} \right)$$

【0023】ただし、 $\alpha = 1 / (C_b \cdot R_{RP})$

本発明に依れば、前記の式により算出した時間 t_{r1} または t_{r2} の内のいずれか一方の時間の間放電する電荷放電量を、前記放電蓄電手段から放電する電荷放電量として決定するので、より正確な電気量を放電することができる。

【0024】

【発明の実施の形態】以下図面を参照して本発明の実施の形態について説明する。

【0025】【第1の実施の形態】図1に示すように、本実施の形態に係る蓄電装置10は、複数の蓄電手段としてのリチウムイオン二次電池（以下「バッテリセル」という）16A、16B、16C、16Nが多数個直列に接続された組電池16として構成されている。なお、図1には、図面の都合上4個のバッテリセルのみを示しているが、実際には図示しない多数のバッテリセルがさらに接続されており、全部で数十個のバッテリセル（本実施の形態ではN個とする）が直列に接続されている。組電池16の一端には、蓄電装置10からの電流供給が行われているか、すなわち、回路12に主電流が流れているかどうかを監視するための監視手段としての電流計14が設置されている。バッテリセル16A、16B、16C、…16Nのプラス端子26A、26C、26E、26Mには、チャージポンプコンデンサ24の一端28Aと接続可能な切換スイッチが接続されており、バッテリセル16A、16B、16C、…16Nのマイナス端子26B、26D、26F、26Nには、チャージポンプコンデンサ24の他端28Bとの接続が可能な切換スイッチが接続されていて、切換スイッチ22を構成している。切換スイッチ22は、チャージポンプコンデンサ24と各バッテリセルとの切換えを制御する制御回路20と接続されている。なお、切換スイッチ22のスイッチとしては、電界効果トランジスタ（FET）やリースイッチなどを使用できる。また、バッテリセル16A、16B、16C、…16Nには、各バッテリセルの電圧を測定するための電圧測定装置18A、18B、18C、…18Nが接続されており、電圧測定装置18A、18B、18C、…18Nは、制御回路20に接続されている。

【0026】次に本実施の形態における作用について、図面を参照しながら説明する。

【0027】本実施の形態では、充電状態の高いバッテリセルから充電状態の低いバッテリセルへチャージポンプコンデンサ24を介して電気を移動させることにより各バッテリセル間の充電状態を均等化する。すなわち、充電状態の高いバッテリセルまたはバッテリセル群（以

下「持出しへセル群」という)から電気を移動させてチャージポンプコンデンサ24に充電し、充電された電気を充電状態の低いバッテリセルまたはバッテリセル群(以下「受取りセル群」という)に放電するという動作を繰り返す。この充電状態均等化処理を、図2に示すフローチャートにしたがって説明する。

【0028】まず、ステップ30で、電流計14により回路12に主電流が流れていなかどうかを判断する。主電流が流れていなければ、ステップ32で電圧測定計18A、18B、18C、…18Nで計測された各バッテリセル16A、16B、16C、…16Nの電圧を読み込んで、制御回路20内の図示しない電圧テーブルに登録する。ここで、各バッテリセルの電圧を測定するのは、バッテリセル内の電気量と電圧とはほぼ比例するので、この電圧値がバッテリセル内の電気量、すなわちバッテリセルの充電状態を示すと考えられるからである。主電流が流れている場合には、前記電圧の測定は行わずに主電流が流れなくなるまで待機する。主電流の流れていないと見計らって電圧の測定を行う必要

$$V^{avg}_{real} = \frac{\sum_{n=1}^N (V_n - V_{min})}{N} + V_{min} \quad (1-1)$$

【0032】ここで、回路中の損失により、チャージポンプコンデンサ24から流れ出す電気量よりも持出しへセル群から流れ出す電気量の方が多いものと考えられるが、このとき持出しへセル群から流れ出す電気量はチャージポンプコンデンサ24から流れ出す電気量に増分係数 $\lambda (>1)$ を乗じたものとして表わす。また、受取りセル群も所定の効率 $\eta (<1)$ でしかチャージポンプコンデンサ24から電気を受け取れないものとする。そこ

$$V^{real}_{avg} = \frac{\frac{\eta}{\lambda} \sum_{n=1}^N (V_n - V_{min})}{N} + V_{min} \quad (1-2)$$

【0034】こうして算出された予想平均電圧(V^{real}_{avg})を目標到達電圧とする。

【0035】なお、前述の例では、予想平均電圧(V^{real}_{avg})を目標到達電圧としたが、本発明はこれに限定されるものではなく、例えば、全バッテリセル電圧の平均値(V_{avg})を求めて、これを目標到達電圧とすることも可能である。

【0036】ステップ36で、持出しへセル群を選択する。ここで選択されるバッテリセルの個数は2であり、隣接する2個のバッテリセルの電圧の和が最大となるものを持出しへセル群として選択する。

【0037】ステップ38で、受取りセル群を選択する。ここで選択されるバッテリセルの個数は1であり、バッテリセルの電圧が最小となるものを受取りセル群として選択する。

があるのは、主電流が流れると各バッテリセルの内部抵抗のために正確な開放電圧が測定できないからである。

【0029】ステップ34で、各バッテリセルの電圧測定値に基いて各バッテリセルの電圧が均等化された場合に到達べき目標到達電圧を設定する。この設定は具体的には以下のように行われる。

【0030】ある時点で測定した各バッテリセルの電圧(V_n)が、図8に示すように分布しているとする。バッテリセルの均等化は、充電状態の高いバッテリセルから充電状態の低いバッテリセルに電気を移動させることにより行うので、最小電圧(V_{min})以上の部分の電気量を移動させることにより行われることになる。このとき電気の移動効率が100% (損失することなし)で行われれば、均等化後の理想平均電圧(V^{avg}_{avg})は、各バッテリセルの最小電圧(V_{min})以上部分の平均電圧に、最小電圧(V_{min})を加えたものに等しくなると考えられるので、以下の式(1-1)により算出する。

【0031】

【数9】

で、移動効率100%の場合を考慮して算出した(1-1)に修正を加え、以下の式(1-2)で均等化後の予想平均電圧(V^{real}_{avg})を算出する。なお、ここで使用する λ 、 η については、実験により計測しておいて、あらかじめ設定しておく。

【0033】

【数10】

【0038】なお、持出しへセル群および受取りセル群の選択個数は、前述したものに限定されるものではなく、任意の個数と選択することができる。また、持出しへセル群および受取りセル群の選択方法も、前述した方法に限定されるものではなく、例えば、最大または最小電圧のバッテリセルを含む隣接したセル群中で、電圧の和が最大または最小のものをそれぞれ持出しへセル群および受取りセル群として選択することができる。また、持出しへセル群としては、最大電圧のバッテリセルを含む隣接したセル群の中の最小電圧セル比較して、該セルのうち電圧の最も高いものを含んだセル群を選択し、受取りセル群としては、最小電圧のバッテリセルを含む隣接したセル群の中の最大電圧セル比較して、該セルのうち電圧の最も低いものを含んだセル群を選択することもできる。

【0039】ステップ40で、持出しへセル群からチャ

ジポンプコンデンサ24を介して受取りセル群に充電した際に、目標到達電圧へ達するまでの時間としての到達予想時間T0を設定する。この到達予想時間T0は、以下に述べる考え方に基いて算出する。

【0040】まず、持出しセル群の個数が2で該当するバッテリセルが16A、16B、受取りセル群の個数が1で該当するバッテリセルが16Nの場合で考える。持出しセル群と受取りセル群の間での均等化動作は、まず持出しセル群とチャージポンプコンデンサ24とを並列に接続してチャージポンプコンデンサ24に充電し、次にチャージポンプコンデンサ24との接続を受取りセル群との並列接続に切換えて、チャージポンプコンデンサ24から受取りセル群に充電する。この均等化動作を繰り返すことで持出しセル群と受取りセル群との電圧を均等化していく。この均等化動作時に、チャージポンプコンデンサ24により移動する電気量を ΔQ とし、バッテリセルが16Aから ΔQ_1 、バッテリセルが16Bから ΔQ_2 の量の電気量が流れ出すとすれば、

$$\Delta Q = \Delta Q_1 + \Delta Q_2 \quad (2-1)$$

となる。ここで、

ΔV_1 ：バッテリセル16Aの電圧変化量（単位：V）

ΔV_2 ：バッテリセル16Bの電圧変化量（単位：V）

C_1 ：バッテリセル16Aの電気容量（単位：F）

C_2 ：バッテリセル16Bの電気容量（単位：F）

とすると、

$$\Delta Q = C_1 \cdot \Delta V_1 + C_2 \cdot \Delta V_2 \quad (2-2)$$

$$\Delta Q = \int_0^{T_1} \frac{C_c \cdot (V_1(t) + V_2(t) - V_r(t))}{T_1} dt \quad (2-3)$$

【0044】となる。

【0045】また、受取りセルであるバッテリセル16Nの電気容量 C_r も前記 C_b に等しく、 $C_r = C_b$ とする。

【0046】ここで、実際は回路中の損失によって、持出しセル群からチャージポンプコンデンサ24に流れ出す電気量は、チャージポンプコンデンサ24に充電される電気量よりも多いため、チャージポンプコンデンサ24に充電される電気量に増分係数 λ （ > 1 ）をかけて表わす。一方、受取りセル群も一定の効率でしか電気を受

$$V_1(t) = V_1 s - \frac{\lambda}{2 \cdot C_b} \int_0^{T_1} C_c \cdot (V_1(t) + V_2(t) - V_r(t)) dt \quad (2-4)$$

$$V_2(t) = V_2 s - \frac{\lambda}{2 \cdot C_b} \int_0^{T_1} C_c \cdot (V_1(t) + V_2(t) - V_r(t)) dt \quad (2-5)$$

$$V_r(t) = V_r s + \frac{\eta - \lambda}{C_b} \int_0^{T_1} C_c \cdot (V_1(t) + V_2(t) - V_r(t)) dt \quad (2-6)$$

【0049】となる。

【0050】この式を、ブロック図で表すと図9のようになる。

【0051】ここで、バッテリセル16の電気容量 C_b や、チャージポンプコンデンサ24の電気容量 C_c などは経過時間によらず、ほぼ一定なので、(2-6)、

となる。ここで使用するバッテリセルは同一規格のものであり、通常、電気容量や内部抵抗などの特性にそれほど差はないので、 $C_1 = C_2 = C_b$ 、 $\Delta V_1 = \Delta V_2$ とする。

【0041】よって、

$$\Delta Q = C_b \cdot \Delta V_1 + C_b \cdot \Delta V_2 \quad (2-3)$$

$$\Delta V_1 = \Delta V_2 = \Delta Q / 2 \cdot C_b \quad (2-4)$$

となる。

【0042】次に、各セルの電圧変化を数式化する。ここで、

$V_1(t)$ ：バッテリセル16Aの時間 t での電圧（単位：V）

$V_2(t)$ ：バッテリセル16Bの時間 t での電圧（単位：V）

$V_r(t)$ ：バッテリセル16Nの時間 t での電圧（単位：V）

$V_1 s$ ：バッテリセル16Aの初期電圧（単位：V）

$V_2 s$ ：バッテリセル16Bの初期電圧（単位：V）

$V_r s$ ：バッテリセル16Nの初期電圧（単位：V）

C_c ：チャージポンプコンデンサ24の電気容量（単位：F）

T_1 ：充放電サイクルの周期（単位：sec）
とすると、

【0043】

【数11】

【0044】となる。

【0045】また、受取りセルであるバッテリセル16Nの電気容量 C_r も前記 C_b に等しく、 $C_r = C_b$ とする。

【0046】ここで、実際は回路中の損失によって、持出しセル群からチャージポンプコンデンサ24に流れ出す電気量は、チャージポンプコンデンサ24に充電される電気量よりも多いため、チャージポンプコンデンサ24に充電される電気量に増分係数 λ （ > 1 ）をかけて表わす。一方、受取りセル群も一定の効率でしか電気を受

け取れず、受取りセル群がチャージポンプコンデンサ24から充電される電気量はチャージポンプコンデンサ24から流れ出す電気量よりも小さいので、チャージポン

プコンデンサ24から流れ出す電気量に減少係数 η （ < 1 ）をかけて表わす。

【0047】以上の、増分係数 λ 、減少係数 η を考慮した場合の各バッテリセル電圧の変化は、

【0048】

【数12】

$$V_1(t) = V_1 s - \frac{\lambda}{2 \cdot C_b} \int_0^{T_1} C_c \cdot (V_1(t) + V_2(t) - V_r(t)) dt \quad (2-6)$$

$$V_2(t) = V_2 s - \frac{\lambda}{2 \cdot C_b} \int_0^{T_1} C_c \cdot (V_1(t) + V_2(t) - V_r(t)) dt \quad (2-7)$$

$$V_r(t) = V_r s + \frac{\eta - \lambda}{C_b} \int_0^{T_1} C_c \cdot (V_1(t) + V_2(t) - V_r(t)) dt \quad (2-8)$$

(2-7)、(2-8)式を解くことで、 $V_1(t)$ 、 $V_2(t)$ 、 $V_r(t)$ の時間変化が計算できる。

【0052】ラプラス変換などを使って解き、また、積分初期値を0として、

【0053】

【数13】

$$\alpha = \frac{\lambda \cdot C c}{C b \cdot T}$$

(2-9)

【0055】

【数14】

【0054】とおくと、

$$V_1(t) = \frac{(1 + 2\eta + e^{-(1+\eta)\alpha t})}{2(1+\eta)} V_1 s - \frac{(1 - e^{-(1+\eta)\alpha t})}{2(1+\eta)} V_2 s + \frac{(1 - e^{-(1+\eta)\alpha t})}{2(1+\eta)} V_r s \quad (2-10)$$

$$V_2(t) = \frac{(1 + 2\eta + e^{-(1+\eta)\alpha t})}{2(1+\eta)} V_2 s - \frac{(1 - e^{-(1+\eta)\alpha t})}{2(1+\eta)} V_1 s + \frac{(1 - e^{-(1+\eta)\alpha t})}{2(1+\eta)} V_r s \quad (2-11)$$

$$V_r(t) = \frac{\eta(1 - e^{-(1+\eta)\alpha t})}{(1+\eta)} (V_1 s + V_2 s) + \frac{(1 + e^{-(1+\eta)\alpha t})}{(1+\eta)} V_r s \quad (2-12)$$

【0056】となる。

【0057】(2-10)から(2-12)式のままでは目標電圧 $V_1(t)$ 等が与えられた時に、それに到達する時刻 t を求めることは困難であるので、これを解きやすいように以下の方法で線形化し近似する。

【0058】ここでは、

$$f(t) = e^{-at} \approx 1 - a \cdot t \quad (2-13)$$

のように近似する。この近似方法に依れば、図10に示すように、 $a \cdot t$ の値が小さい時ほど近似度が高く、また、実際の変化より大き目に見積もることになるので、変化の予想としては安全側に見積もることになる。ま

た、実際には電圧が最終的に収束するところまで使われず、 $a \cdot t$ が小さい領域だけを使うことになるので実用上は問題ないと思われる。

【0059】なお、この近似は図9のブロック図において、積分の代わりに、時間 t に比例とすると置き換えたと見ることもできる。

【0060】式(2-13)を使って(2-10)から(2-12)式を近似すると、

【0061】

【数15】

$$V_1(t) = V_1 s + \frac{\alpha}{2} (V_r s - (V_1 s + V_2 s)) \cdot t \quad (2-14)$$

$$V_2(t) = V_2 s + \frac{\alpha}{2} (V_r s - (V_1 s + V_2 s)) \cdot t \quad (2-15)$$

$$V_r(t) = V_r s + (V_1 s + V_2 s - V_r s) \eta \cdot \alpha \cdot t \quad (2-16)$$

【0062】と簡略化される。

【0063】ここで、 $V_1(t)$ 、 $V_2(t)$ 、 $V_r(t)$ などが与えられた時に、それに達する時刻は t_1 、 t_2 、

 t_r は、

$$t_1 = \frac{2(V_1 s - V_1(t))}{\alpha(V_1 s + V_2 s - V_r s)} \quad (2-17)$$

$$t_2 = \frac{2(V_2 s - V_2(t))}{\alpha(V_1 s + V_2 s - V_r s)} \quad (2-18)$$

$$t_r = \frac{(V_r(t) - V_r s)}{\eta \cdot \alpha(V_1 s + V_2 s - V_r s)} \quad (2-19)$$

【0064】

【数16】

【0065】のように求められる。

【0066】なお、上述の例では、持ち出しセル数が2個、受け取りセル数が1個の場合で考えたが、持ち出しセル数がN個、受け取りセル数がM個の場合には、式

(2-14)、(2-16)および(2-17)、(2-19)

式は以下のように表わすことができる。

$$V_n(t) = V_n s + \frac{\alpha}{N} \left(\sum_{m=1}^N V_r m s - \sum_{n=1}^N V_n s \right) \cdot t \quad (2-20)$$

$$V_r m(t) = V_r m s + \frac{\eta \cdot \alpha}{M} \left(\sum_{n=1}^N V_n s - \sum_{m=1}^M V_r m s \right) \cdot t \quad (2-21)$$

【0068】

【数18】

13

$$t_n = \frac{N(V_n s - V_n(t))}{\alpha(\sum_{n=1}^N V_n s - \sum_{m=1}^M V_m s)}$$

$$t_m = \frac{M(V_m(t) - V_m s)}{\eta \cdot \alpha(\sum_{n=1}^N V_n s - \sum_{m=1}^M V_m s)}$$

14

(2-22)

(2-23)

【0069】よって、本ステップ40では、到達予想時間T0として(2-22)、(2-23)のいずれか短い方を設定する。

【0070】ステップ42で、図3に示す均等化動作を行なう。具体的には、ステップ52で、電圧の和が最大となるバッテリセル16A、16Bの持出しセル群とチャージポンプコンデンサ24とを並列に接続すべく、バッテリセルの端子26Aとチャージポンプコンデンサ24の端子28A、バッテリセルの端子26Dとチャージポンプコンデンサ24の端子28Bとが接続されるように切換え接続部22を制御する。すると、持出しセル群からチャージポンプコンデンサ24に充電が行われるが、ステップ54で、チャージポンプコンデンサ24に容量分の電気量が蓄えられたかどうかを判断する。チャージポンプコンデンサ24に容量分の電気量が蓄えられると、持出しセル群とチャージポンプコンデンサ24との接続が解除されて、ステップ56で、受取りセル群とチャージポンプコンデンサ24とが並列に接続される。ここでは、バッテリセルの端子26Mとチャージポンプコンデンサ24の端子28Aとが、バッテリセルの端子26Nとチャージポンプコンデンサ24の端子28Bとが接続されるように切換え接続部22を制御する。すると、チャージポンプコンデンサ24から、受取りセル群であるバッテリセル16Nに充電が行われる。ステップ58で受取りセル群への充電が終了したかどうかを判断し、受取りセル群への充電が終了した場合には、図2のステップ44へ進む。ここで、図3に示す1回の均等化動作が充放電の1サイクルであり、この1サイクルに要する時間が、前述の1充放電サイクルの周期T1に該当する。

【0071】図2のステップ44で到達予想時間T0に達したかどうかを判断する。到達予想時間T0に達していない場合には、持出しセル群、受取りセル群とともに、設定された目標電圧に到達していないため、ステップ42の均等化動作を繰り返す。到達予想時間T0に達した場合には、ステップ46で到達予想時間T0に基づいて持出しセル群であったバッテリセル16A、16B、受取りセル群であったバッテリセル16Nの均等化動作後の電圧値を算出し、ステップ48で前記電圧テーブルの電圧値を入れ換える。ここで、電圧値が、目標電圧に達したバッテリセルの電圧は、前記電圧テーブルから削除していく。ステップ50で、次のセル群の均等化を行うかどうかを判断する。ここで、次のセル群の均等化を行うかどうかは、次のようにして判断する。すなわち、電

圧テーブルから順次目標電圧に到達したバッテリセルが削除されていくので、持出しセル群または受取りセル群のどちらか一方のバッテリセルのすべてが削除された場合には、次のセル群の均等化は行わず、本処理を終了する。電圧テーブルに持出しセル群および受取りセル群の双方が残っている場合には、次の均等化処理を行うために、ステップ36にもどり、以下の処理を繰り返す。

【0072】本実施の形態に依れば、主電流が流れていないとバッテリセルの電圧を測定するので、バッテリセルのより正確な開放電圧を測定することができる。したがって、この正確な開放電圧に基づいてより適切な持出しセル群および受取りセル群を選択することができる。

【0073】また、前述のように、主電流の流れていないとバッテリセルの電圧を測定し、この電圧に基づいて目標電圧、到達予想時間、電圧均等化後のバッテリセル電圧を算出して均等化処理をスケジュール化するので、1均等化サイクル毎にバッテリセル電圧を測定する必要がなく、主電流が流れているか否かを問わず、必要なときにバッテリセル電圧の均等化を行うことができる。さらに、到達予想時間の算出は、電圧均等化動作中のバッテリセル電圧の電圧変化を考慮した後に近似させる方法を用いて行っているので、より正確な電圧均等化処理を行うことができる。

【0074】【第2の実施の形態】第2の実施の形態について、第1の実施の形態と同様の部分に付いては、説明を省略する。

【0075】本実施の形態に係る作用を、図4、図5を参照しながら説明する。

【0076】図5に示すセル電圧読みルーチンは、一定時間(例えば10分毎)にスタートする。ステップ30、ステップ32では、第1の実施の形態と同様にして各バッテリセルの電圧を電圧テーブルに保存する。ステップ70で、前記電圧テーブルが更新されたことを示す電圧データフラグをセットし、本セル電圧読みルーチンは終了する。ここで保存された各バッテリセル電圧データに基づいて、図4に示す電圧均等化処理を行う。

【0077】ステップ60で、前記電圧テーブルに保存されている電圧データを読み込む。ステップ62で、セット済みの電圧データフラグをリセットする。ステップ34からステップ48までは、第1の実施の形態と同様に行なう。ステップ64で、電圧データフラグがセットされているかどうかを判断する。ここで、電圧データフラグがセットされている場合には、均等化動作中に新たに

セル電圧が読み取られている。すべてのセル電圧の均等化処理が終了するまでには、かなりの時間がかかることがある。その間の温度分布の変化などにより、各バッテリセル電圧は当初測定した時とは入れ替わっていることがある。そこで、一定時間毎に更新される電圧データに基づいて均等化処理を継続すべく、電圧データフラグがセットされている場合には、ステップ60へもどり、再び電圧テーブルの読み込みを行って、以下の処理を繰り返す。電圧データフラグがセットされていない場合には、電圧テーブルのデータが更新されていないので、第1の実施の形態と同様にしてステップ36にもどり、以下の処理を繰り返す。

【0078】本実施の形態に依れば、均等化処理中の一定時間毎に各バッテリセル電圧を測定して電圧データを更新し、電圧均等化処理のスケジュール化を図るので、より正確な電圧均等化処理を行うことができる。

【0079】 [第3の実施の形態] 第2の実施の形態についても、第1、第2の実施の形態と同様の部分については、説明を省略する。

【0080】本実施の形態に係る作用を、図6、図7を参照しながら説明する。

【0081】図6に示す電圧均等化処理の、ステップ30からステップ34は、前述の第1の実施の形態と同様にして行う。ステップ80で、図7に示す持出し・受取りセル選択処理を行う。

【0082】ステップ82で、目標電圧 V_{obj} より高い電圧のバッテリセルを選択し、電圧の大きいセルから順に V^{pl}_k 、 V^{pl}_1 …と順位づけする。ステップ84で、目標電圧 V_{obj} より低い電圧のバッテリセルを選択し、電圧の小さいセルから順に V^{hl}_1 、 V^{hl}_2 …と順位づけする。ここで、 k 、 1 、… i 、 j は、バッテリセルの位置に基づいて端から順に付けたセル番号のいずれかであり、一端に位置するセル1から順にバッテリセルはN個設けられ、他端にはセルNが位置している。ステップ86で、最もセル電圧の高いバッテリセル V^{pl} が、端に位置するセルかどうか、すなわち、 $k=1$ もしくは $k=N$ かどうかを判断する。バッテリセル V^{pl} が、端に位置するセルでない場合には、該セルの両端のセルの電圧 V_{k+1} および V_{k-1} が、目標電圧 V_{obj} よりも大きいかどうかを判断する。セル $k+1$ および $k-1$ の電圧 V_{k+1} および V_{k-1} が、目標電圧 V_{obj} よりも大きい場合には、ステップ90で、 $V_{k+1} > V_{k-1}$ かどうかを判断する。 $V_{k+1} > V_{k-1}$ の場合には、 $k+1$ と k とのセル群の電圧の和 $V_{k+1} + V_k$ が、 k と $k-1$ とのセル群の電圧の和 $V_{k-1} + V_k$ よりも大きいので、ステップ98で、持出しセルとして、 $k+1$ および k を選択する。 $V_{k+1} > V_{k-1}$ でない場合には、 $k-1$ と k とのセル群の電圧の和 $V_{k-1} + V_k$ が、 $k+1$ と k とのセル群の電圧の和 $V_{k+1} + V_k$ よりも大きいので、ステップ100で、持出しセルとして、 $k-1$ および k を選択する。ステップ88で、セル $k+1$ および $k-1$ の

電圧 V_{k+1} および V_{k-1} の少なくとも一方が、目標電圧 V_{obj} よりも小さい場合には、ステップ 9 4 で、セル $k+1$ の電圧 V_{k+1} が目標電圧 V_{obj} よりも大きいかどうかを判断する。セル $k+1$ の電圧 V_{k+1} が目標電圧 V_{obj} よりも大きい場合には、前述のステップ 9 8 で持出しセルとして、 $k+1$ および k を選択する。セル $k+1$ の電圧 V_{k+1} が目標電圧 V_{obj} よりも小さい場合には、ステップ 9 6 で、セル $k-1$ の電圧 V_{k-1} が目標電圧 V_{obj} よりも大きいかどうかを判断する。セル $k-1$ の電圧 V_{k-1} が目標電圧 V_{obj} よりも大きい場合には、前述のステップ 1 0 0 で、持出しセルとして、 $k-1$ および k を選択する。セル $k-1$ の電圧 V_{k-1} が目標電圧 V_{obj} よりも小さい場合には、セル $k+1$ および $k-1$ の電圧 V_{k+1} および V_{k-1} の双方が目標電圧 V_{obj} よりも小さいので、持出しセルとしては選択せず、ステップ 1 0 2 でセル k のみを持出しセルとして選択する。また、ステップ 8 6 で、最高電圧のセル V^{pl} が組蓄電池の一端に位置する場合、すなわち、 $k=1$ または $k=N$ と判断した場合には、ステップ 9 2 で、セル k が $k=1$ の位置にあるかどうかを判断する。セル k が $k=1$ であった場合には、 $k=k-1$ のセルは存在しないので、前述したステップ 9 4 へ進み以下の処理を行う。セル k が $k=1$ でない場合には、 $k=N$ であり、 $k=k+1$ のセルは存在しないので、前述したステップ 9 6 へ進み以下の処理を行う。前述のようにして持出しセル群を決定した後に、ステップ 1 0 4 で、セル電圧の最も低いバッテリセルを受取セルとして選択する。ステップ 4 4 以下は第 1 の実施の形態と同様に処理を行い、本処理を終了する。

【0083】本実施の形態に依れば、持出しセルの選択の際に、目標電圧 V_{obj} よりも電圧の低いバッテリセルは選択しないようにするので、より適切に高い電圧の持出しセル群を構成することができ、その結果持出しセル群と受取りセル群との電圧差も大きくなり、より迅速に電圧の均等化処理を行うことができる。

【0084】【第4の実施の形態】第4の実施の形態についても、前述の実施の形態と同様の部分についても、同様の記号を付して説明を省略する。

【0085】図11に示すように、バッテリセル16A、16B、16C……16Nには、それぞれ抵抗器78とスイッチ76とが直列に接続された回路（以下「放電回路」という）が、並列に接続されている。この放電回路74は、スイッチ76をオンし、各バッテリセルの充電電荷を抵抗器78を介して放電させることにより各バッテリセルの充電状態の均等化を行うものである。制御回路20は、スイッチ76A、76B、76C……76Nと接続されており、各スイッチのオン・オフを制御する。前述の実施の形態に係る蓄電装置に設置されたチャージポンプコンデンサ24および切換え接続部22は備えていない。

【0086】図12(A)は、1つのバッテリセル16Aに接続された放電回路74を示す。スイッチ76A

のオン時には、放電回路74にW方向に電流が流れる（この電流を以下「バイパス電流」）という。バッテリセル16Aの内部には内部抵抗R_{in}が存在し、バッテリセル16Aの内部は図12（B）のように示すことができる。

【0087】ここで、各放電回路74に設置された抵抗器78A、78B、78C……78Nの抵抗値は、バッテリセル16A、16B、16C、……16Nの内部抵抗と比較して十分大きい値とする。通常1000～10000倍程度とするのが望ましいが、最低でも100倍程度とする必要がある。

【0088】次に本実施の形態における作用について図14に示すフローチャートにしたがって説明する。

【0089】ステップ30からステップ34は、前述の実施の形態と同様に処理を行う。ステップ10で、各セル毎に目標電圧への到達予想時間t_r～t_nを設定する。具体的には、以下の考え方に基づいて算出する。

【0090】まず、図12（A）に示す放電回路74において、スイッチ76Aがオンされているときのバイパス電流I_{BP}は、時間tでのバッテリセル電圧をV_b(t)、放電回路抵抗値をR_{BP}として、

【0091】

【数19】

$$I_{BP} = \frac{V_b(t)}{R_{BP}} \quad (3-1)$$

$$V_b(t) = V_s - \frac{1}{C_b \cdot R_{BP}} \int_0^t V_b(t) \cdot dt \quad (3-2)$$

【0100】1/(C_b · R_{BP}) = αとおいて、式(3-4)をラプラス変換、ただし、積分初期値は0とすると、

$$V_b(s) = V_s - \frac{\alpha}{s} V_b(s)$$

【0102】(3-5)式より、またV_s = V_s/sとおくと(単位ステップ入力V_s倍)、

$$V_b(s) = \frac{1}{s + \alpha} V_s$$

【0104】を得る。式(3-6)を逆ラプラス変換し
V_b(t) = V_s · e^{-αt}を得られ、このようにして、t時間後のバッテリセル電圧の変化が予測できる。

【0105】目標電圧V_rが与えられた時に、それに到達するに要する時間t_rは(3-7)式より、

【0106】

【数24】

$$t_r = -\frac{1}{\alpha} \ln \left(\frac{V_b r}{V_s} \right) \quad (3-8)$$

【0107】として得られる。

【0108】ここで、(3-7)においてe^{-αt} ≈ 1 - α · tの近似を行うと、目標電圧V_bが与えられた時、そこに達するのに要する時間t_rは、

【0092】となる。

【0093】バイパス電流I_{BP}によるバッテリセル16Aの電気量(Q_b)の初期容量(Q_s)からの変化分(ΔQ)は、

【0094】

【数20】

$$\Delta Q = Q_s - Q_b(t) = \int_0^t I_{BP} \cdot dt \quad (3-2)$$

【0095】となる。

【0096】また、バッテリセル16Aの容量C_bは、バッテリセル電圧V_bおよびバッテリセル16Aの初期電圧V_sの変化によらず一定として考えられ、バッテリセル電圧V_bの変化によりバッテリセル16Aの電気量変化分ΔQは

$$\Delta Q = C_b \cdot (V_s - V_b(t)) \quad (3-3)$$

【0097】通常、バッテリセルの電気量Qとバッテリセル電圧(解放電圧)Vとは、リチウムイオン電池の場合、図13のように変化するが、狭い範囲の間(図13のΔV1、ΔV2)でならば、その関係はほぼ比例すると見て良い。また、C_bの値は、VあるいはQの領域によりいくつか用意してもよい。

【0098】(3-1)、(3-2)、(3-3)より、

【0099】

【数21】

$$(3-4)$$

【0101】

【数22】

$$(3-5)$$

【0103】

【数23】

$$(3-6)$$

て、

$$(3-7)$$

【0109】

【数25】

$$t_r = \frac{1}{\alpha} \ln \left(1 - \frac{V_b r}{V_s} \right) \quad (3-9)$$

【0110】で与えられ、対数を用いない簡単な式で予測可能である。この時間だけ放電回路をオンすれば、当初、目標とした所定の電圧に持っていくことができる。

【0111】ここで、αが小さい(C_bが大、78Aが大)、あるいはt_rが小さければ、近似度としては高いことになるので、近似を行う場合には注意する必要がある。

【0112】以上のようにして式(3-9)により目標電

圧 V_r に到達時間するために要する各バッテリセル毎の時間（到達予想時間） $t_r 1 \sim t_r n$ を設定することができる。なお、近似を行う前の式（3-8）により算出される時間を到達予想時間 $t_r 1 \sim t_r n$ とすることもできる。

【0113】ステップ112で、各バッテリセルの放電回路74に設けられたスイッチ76A、76B、76C ……76Nを前述のようにして算出した到達予想時間だけオンする。放電回路のスイッチをオンすると、放電回路にバイパス電流が流れ、抵抗器78A、78B、78C ……78Nから放電が開始される。この放電を前記到達予想時間だけ行うことにより、各バッテリセルの電圧は、目標電圧になり均等化される。

【0114】ここで、主電流が流れる場合には、主電流が流れることによってバッテリセル電圧が変動するので、その影響を考慮しておく。

【0115】図12（B）に示すように、電池内部抵抗を R_{IN} 、主電流を I_M とすると、この時、主電流 I_M のうち放電回路74に流れる電流分 I_{MBP} は

【0116】

【数26】

$$I_{MBP} = \frac{R_{IN}}{R_{IN} + R_{BP}} I_M \quad (3-10)$$

【0117】となる。そこで、電池内部抵抗 R_{IN} が十分小さいか、または抵抗器78Aの抵抗値 R_{BP} が十分大きければ、放電回路74に流れる電流分 I_{MBP} は十分小さく、主電流 I_M が流れても、バイパス電流 I_{BP} に影響を与えないことになる。

【0118】通常電池内部抵抗 R_{IN} は $3 \sim 5 \text{ m}\Omega$ 程度なので、抵抗器78Aの抵抗値 R_{BP} を $30 \sim 50 \Omega$ 程度に選べば、主電流 I_M が 50 A の時、放電回路74に流れる電流分 I_{MBP} は 5 mA 程度 (I_M の $1/1000$) となるが、もともとバイパス電流 I_{BP} は電池電圧 3.6 V で $20 \sim 72 \text{ mA}$ なので、放電回路74に流れる電流分 I_{MBP} の 5 mA は 7% 程度となる。また、主電流 I_M は、特に、ハイブリッド車の場合、常に同一方向に流れているわけではなく、平均的にはプラス、マイナス同じ程度と考えられるので、実際上、放電回路74に流れる電流分 I_{MBP} への影響もプラスマイナス両方に働き、さらに小さいものと考えられる。よってこの場合でも、主電流が流れしたことによる変動分は考慮しなくてもよいことが分かる。なお、抵抗器78の抵抗値 R_{BP} は、最低でも電池内部抵抗 R_{IN} の 100 倍程度とする必要があり、通常 $1000 \sim 10000$ 倍程度とするのが望ましい。

【0119】ステップ114で、すべてのバッテリセルについて到達予想時間が経過したかどうかを判断する。すべてのバッテリセルについて到達予想時間が経過していない場合には、該到達予想時間が経過するまで待機し、到達予想時間が経過した場合には、本処理を終了する。

【0120】本実施の形態に依れば、より簡素な回路（放電回路）とすることができる、低成本で電圧の均等化を行うことができる。また、放電回路の抵抗器の抵抗値を、バッテリセル内部の抵抗値と比較して十分大きい値としたので、主電流が流れても放電回路中に流れる電流値に及ぼす影響は少なく、主電流が流れているか否かにかかわらず電圧均等化処理を行うことができるとともに、放電回路中を流れる電流の絶対値も小さくなり、発熱対策が不要になるという効果も得ることができる。さらに、本実施の形態に依れば、目標電圧への到達予想時間すなわち抵抗器から放電する時間の算出を、放電中にバッテリセル電圧が変化しバイパス電流値も変化することが考慮されて行うので、より正確な量の放電を行うことができ、より適切に放電を行うことができる。

【0121】

【発明の効果】以上説明したように本発明によれば、前記蓄電手段から電流が流れていらないときに検出された前記蓄電手段の各々の電圧、すなわち、前記蓄電手段がその内部抵抗等により影響を受けていない状態での正確な電圧に基いて前記蓄電手段を均等化するので、正確に適切な均等化を行うことができる、という有利な効果を有する。

【図面の簡単な説明】

【図1】 第1、第2、第3の実施の形態における蓄電装置の回路図である。

【図2】 第1の実施の形態に係る電圧均等化処理を示すフローチャートである。

【図3】 第1の実施の形態に係る電圧均等化処理の一部示すフローチャートである。

【図4】 第2の実施の形態に係る電圧均等化処理を示すフローチャートである。

【図5】 第2の実施の形態に係るセル電圧読み込み処理を示すフローチャートである。

【図6】 第3の実施の形態に係る電圧均等化処理を示すフローチャートである。

【図7】 第3の実施の形態に係る電圧均等化処理の一部示すフローチャートである。

【図8】 セル電圧の分布と電圧均等化後の平均電圧との関係を示すグラフである。

【図9】 均等化動作中のセル電圧変化を示すブロック図である。

【図10】 $f(t) = e^{-at}$ と $f(t) = 1 - at$ との関係を示すグラフである。

【図11】 第4の実施の形態に係る蓄電装置の回路図である。

【図12】 第4の実施の形態に係る1バッテリセルの放電回路図である。

【図13】 第4の実施の形態における電池電圧と電池容量との関係を示すグラフである。

【図14】 第4の実施の形態に係る電圧均等化処理を

示すフローチャートである。

【符号の説明】

10 蓄電装置

14 電流計 (検知手段)

16A、16B、16C…16N バッテリセル (蓄電手段)

18A、18B、18C…18N 電圧測定器 (電圧段)

検出手段)

20 制御回路 (制御手段)

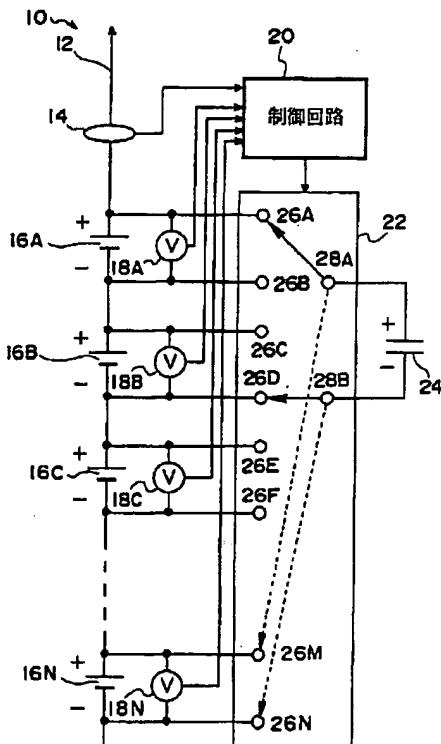
22 切換接続部

24 蓄電器

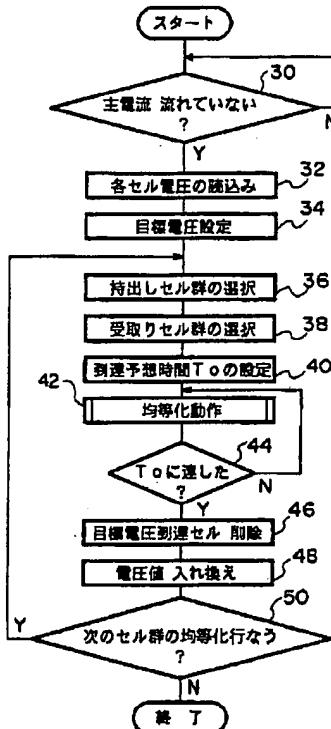
76A、76B、76C…76N スイッチ

78A、78B、78C…78N 抵抗器 (放電手段)

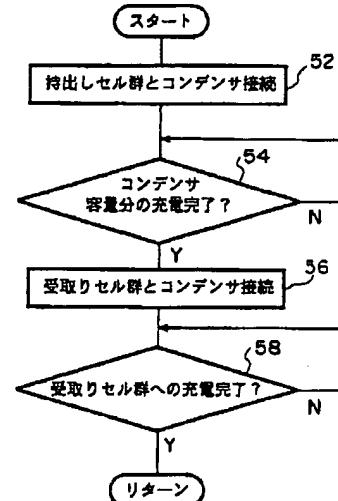
【図1】



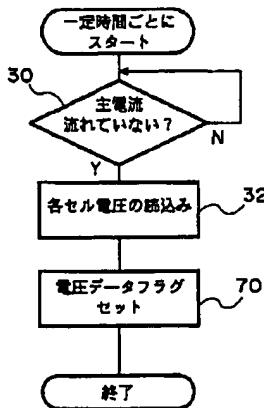
【図2】



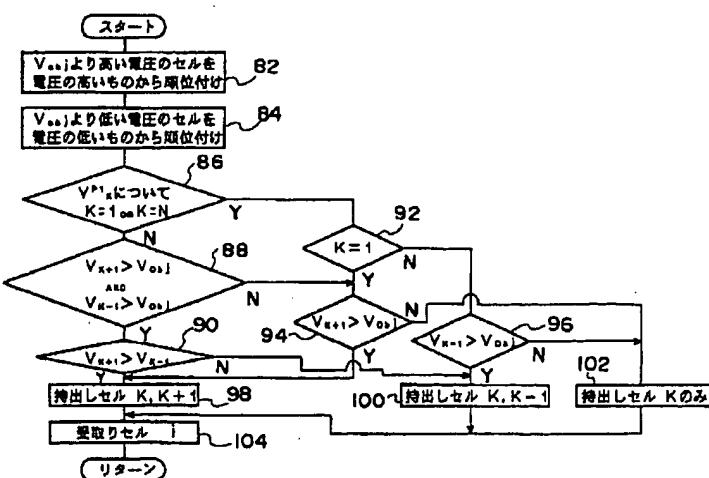
【図3】



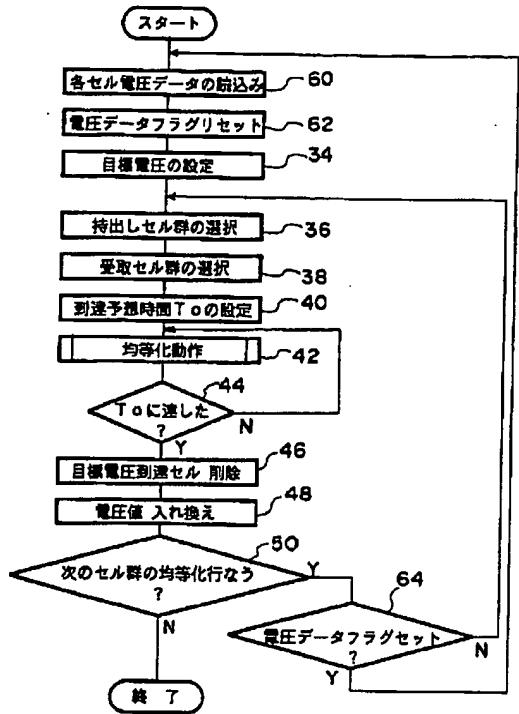
【図5】



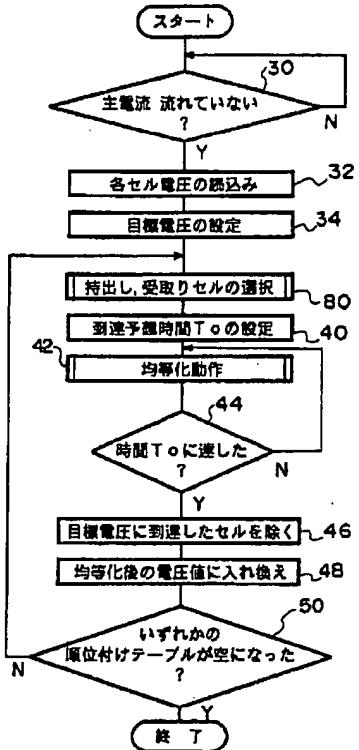
【図7】



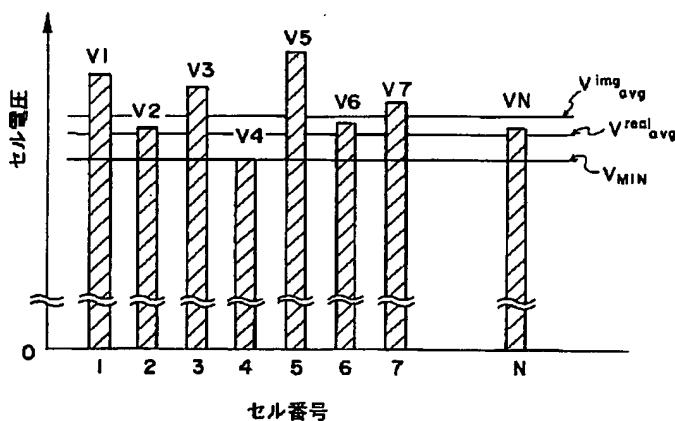
【図4】



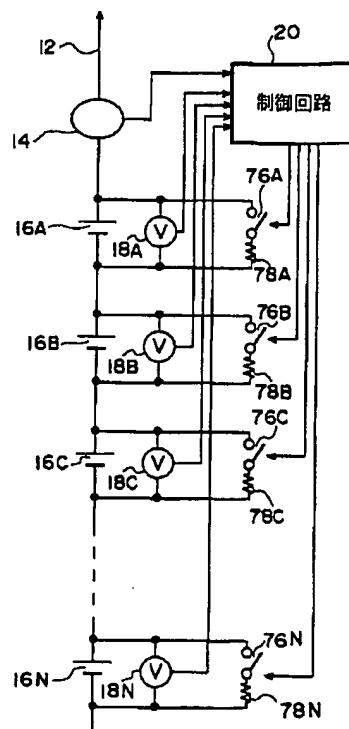
【図6】



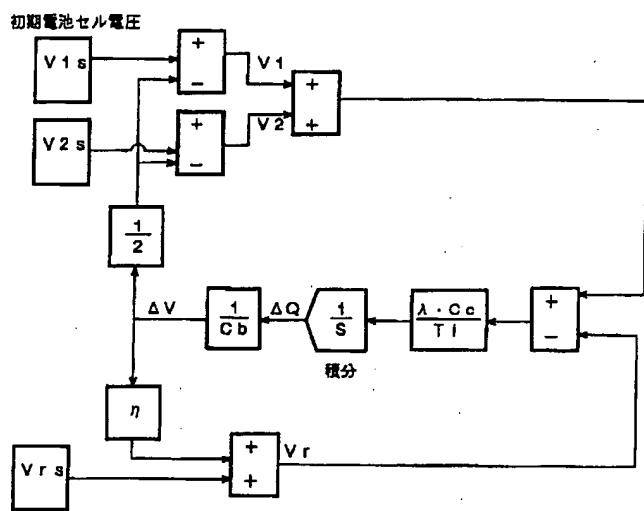
【図8】



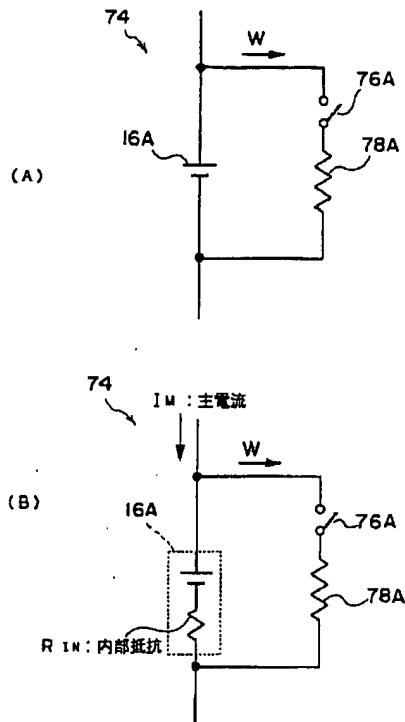
【図11】



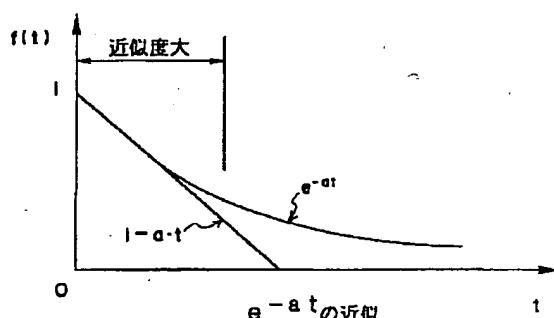
【図9】



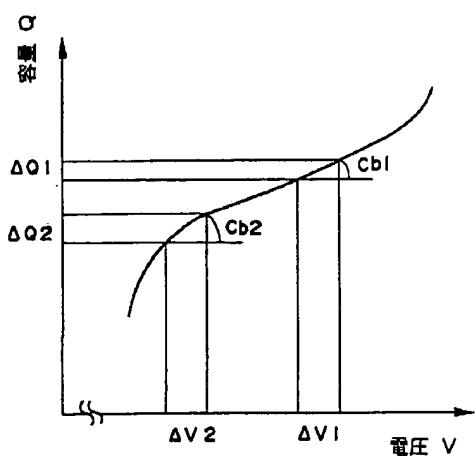
【図12】



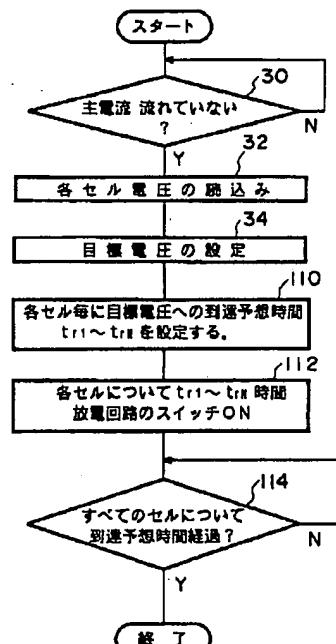
【図10】



【図13】



【図14】



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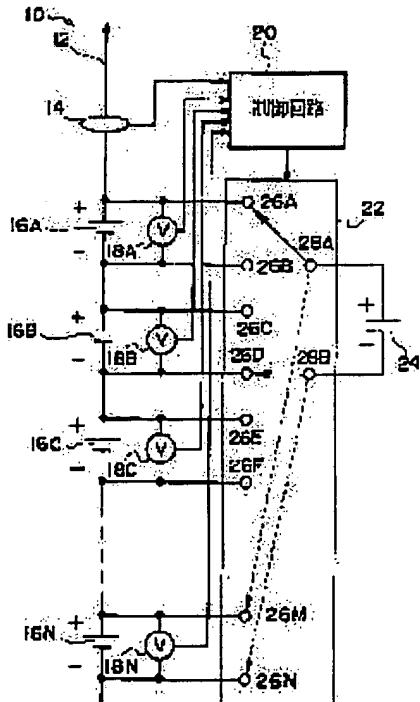
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(54) STORAGE DEVICE



(57)Abstract:

PROBLEM TO BE SOLVED: To equalize a plurality of storing means connected in series exactly and properly.

SOLUTION: The respective voltages of a plurality of battery cells 16 connected in series are detected when no current runs through a circuit 12. Based on the detected voltage, the determination of a charge carrying-out cell and a charge receiving cell and the calculation of equalization operating time are performed to schedule the charging equalization operation of the respective battery cells.

* NOTICES *

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1. This document has been translated by computer. So the translation may not reflect the original precisely.

2. **** shows the word which can not be translated.

3. In the drawings, any words are not translated.

CLAIMS

[Claim(s)]

[Claim 1] Two or more accumulation-of-electricity means connected to the serial, and an electrical-potential-difference detection means to detect each electrical potential difference of said accumulation-of-electricity means, It is based on each electrical potential difference of said accumulation-of-electricity means detected by detection means to detect whether the current is flowing from said accumulation-of-electricity means, and said electrical-potential-difference detection means when being detected as the current not flowing with said detection means. Accumulation-of-electricity equipment equipped with an equalization means to equate the amount of accumulation of electricity of two or more of said accumulation-of-electricity means.

[Claim 2] A migration means by which said equalization means moves a charge to said other at least one accumulation-of-electricity means through said capacitor from each of said accumulation-of-electricity means, a connectable capacitor, and said at least one accumulation-of-electricity means, A receipt accumulation-of-electricity means to receive an emission accumulation-of-electricity means to emit a charge for the amount of accumulation of electricity of two or more of said accumulation-of-electricity means to become equal based on each electrical potential difference of said accumulation-of-electricity means, and the emitted charge, Accumulation-of-electricity equipment [equipped with a decision means to determine the amount of charge transfer from this emission accumulation-of-electricity means to this receipt accumulation-of-electricity means, and the control means which controls said migration means so that the amount of charge transfer determined by said decision means moves to said receipt accumulation-of-electricity means from said emission accumulation-of-electricity means] according to claim 1.

[Claim 3] Said decision means the n-th electrical potential difference of N and said emission accumulation-of-electricity means for the number of said emission accumulation-of-electricity means Vns, The m-th electrical potential difference of Vn (t) and said receipt accumulation-of-electricity means for the n-th target electrical potential difference of said emission accumulation-of-electricity means after equalization Vrms, The m-th target electrical potential difference of said receipt accumulation-of-electricity means after equalization Vrm (t), The period with which migration of a charge is carried [electric capacity / of said accumulation-of-electricity means] out to said receipt accumulation-of-electricity means from said emission accumulation-of-electricity means through Cc and said capacitor in the electric capacity of Cb and said capacitor Ti, The multiplier in consideration of a part for the charge loss at the time of moving a charge to said capacitor from said emission accumulation-of-electricity means eta, The multiplier in consideration of a part for the charge loss at the time of moving a charge to said receipt accumulation-of-electricity means from said capacitor lambda, either of the time amount tn and tm which was carried out and was computed from the following two formulas -- the accumulation-of-electricity equipment according to claim 2 characterized by determining the charge which moves by moving a charge with said migration means between short time amount as said amount of charge transfer.

[Equation 1]

However, [Equation 2]

[Claim 4] A discharge means by which said equalization means discharges quantity of electricity from said accumulation-of-electricity means, A discharge accumulation-of-electricity means to discharge quantity of electricity for the amount of accumulation of electricity of two or more of said accumulation-of-electricity means to become equal based on each electrical potential difference of said accumulation-of-electricity means, Accumulation-of-electricity equipment [equipped with a decision means to determine the amount of charge discharge which discharges from this discharge accumulation-of-electricity means, and the control means which controls said discharge means so that the amount of charge discharge determined by said decision means discharges from said discharge accumulation-of-electricity means] according to claim 1.

[Claim 5] Said discharge means is accumulation-of-electricity equipment according to claim 4 with which the resistance for consuming the charge from said accumulation-of-electricity means is characterized by having the resistance of 100 times or more of the resistance inside said accumulation-of-electricity means.

[Claim 6] Said decision means is accumulation-of-electricity equipment according to claim 5 characterized by to determine quantity of electricity which discharges between the time amount of either of the time amount tr1 or tr2 which set [the electric capacity of Vr and said accumulation-of-electricity means] the resistance of the VS aforementioned resistor to RBP for the electrical potential difference of Cb and said accumulation-of-electricity means, and computed the target electrical potential difference after equalization from the following two formulas as an amount of charge discharge which discharges with said discharge means.

[Equation 3]

[Equation 4]

However, $\alpha = 1/(C_b - R_{BP})$

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to accumulation-of-electricity equipment,

and relates to the possible accumulation-of-electricity equipment of equating the charge condition between each battery of the accumulation-of-electricity equipment which connected two or more batteries to the serial more.

[0002]

[Description of the Prior Art] As a power source of the electric vehicle with which ED is furthered in recent years, the accumulation-of-electricity equipment (group cell) which connected two or more batteries to the serial is used. Thus, in order to depend for an output on the cell of the lowest electrical potential difference in the case of the accumulation-of-electricity equipment which connected many batteries to the serial, if dispersion is in the charge condition of each cell, each cell cannot be used equally, but there is un-arranging [that capacity of each cell cannot be demonstrated to the maximum extent].

[0003] Then, various electrical-potential-difference balancing circuits are proposed that the charge condition of each cell should be conventionally made homogeneity. For example, in what is indicated by JP,10-322925,A, a discharge circuit is prepared for every cell and the open circuit voltage of each cell is detected, and it adjusts so that quantity of electricity of each cell may be discharged by the discharge circuit based on this open circuit voltage and the charging rate of each cell may become homogeneity. Moreover, in what is indicated by JP,11-103534,A, the capacitor in which parallel connection is possible is formed in each cell, and after detecting the open circuit voltage of each cell, the cell which receives discharge is chosen from the cell which charges a capacitor, and a capacitor. And the near cell and near capacitor which are charged first are connected, it charges at a capacitor, the near cell and near capacitor which receive discharge next are connected, and this cell is charged. The charging rate between each cell was adjusted by performing this processing cycle the count of predetermined (the number of assignment cycles). [0004]

[Problem(s) to be Solved by the Invention] However, in the advanced technology currently indicated by above-mentioned JP,10-322925,A, since it is premised on discharge quantity of electricity being proportional to the time amount which passes a current in a discharge circuit, it is not taken into consideration that the current which flows in a discharge circuit with the fall of the cell voltage by discharge also falls. Therefore, quantity of electricity was not able to be discharged from a cell by the exact time amount according to quantity of electricity which should discharge. Moreover, since it was not taken into consideration about the relation between the resistance of a discharge circuit, and the resistance inside a cell, when the ratio of the resistance of a discharge circuit and the resistance inside a cell was small, and a current flowed a main circuit, as compared with the case where (it being called "principal current" below) and principal current are not flowing, a lot of currents flowed in the discharge circuit, and it was in it un-arranging [of having discharged a lot of quantity of electricity than target discharge quantity of electricity].

[0005] Moreover, in the advanced technology currently indicated by JP,11-103534,A, each cell voltage for choosing the cell which charges a capacitor, and the cell which receives a capacitor to discharge is detected irrespective of whether principal current is flowing for every number of assignment cycles of electrical-potential-difference equalization processing. In the condition of not flowing with the condition that principal current is flowing, since cell voltage was changed, exact open circuit voltage of each cell

could not be measured, and the cell which charges a capacitor, and the cell which receives a capacitor to discharge were not able to be chosen correctly. Then, although measuring an electrical potential difference and carrying out electrical-potential-difference equalization processing is also considered while principal current is not flowing, while the cell which the number of assignment cycles of electrical-potential-difference equalization processing detects cell voltage frequently, and charges a capacitor comparatively short therefore, and the cell which receives a capacitor to discharge must be chosen and principal current is not flowing in fact for a long time, electrical-potential-difference equalization processing will be carried out at the time of a car halt. Now, effectiveness of electrical-potential-difference equalization processing was not fully able to be demonstrated [that electrical-potential-difference equalization processing can carry out only at the time of a car halt, and].

[0006] This invention is [0007] aiming at offering the possible accumulation-of-electricity equipment of it being made in view of the above-mentioned fact, and performing more electrical-potential-difference equalization processing of each accumulation-of-electricity means to accuracy.

[Means for Solving the Problem] In order to attain the above-mentioned purpose, the accumulation-of-electricity equipment concerning this invention Two or more accumulation-of-electricity means connected to the serial, and an electrical-potential-difference detection means to detect each electrical potential difference of said accumulation-of-electricity means, It is based on each electrical potential difference of said accumulation-of-electricity means detected by detection means to detect whether the current is flowing from said accumulation-of-electricity means, and said electrical-potential-difference detection means when being detected as the current not flowing with said detection means. It is constituted including an equalization means to equate the amount of accumulation of electricity of two or more of said accumulation-of-electricity means.

[0008] If it depends on this invention, since said accumulation-of-electricity means will be equated based on each electrical potential difference of said accumulation-of-electricity means detected while the current was not flowing from said accumulation-of-electricity means, i.e., the exact electrical potential difference in the condition that said accumulation-of-electricity means is not influenced with the internal resistance etc., suitable equalization can be performed correctly.

[0009] Equalization means decreasing dispersion in the charge condition of said accumulation-of-electricity means, and it says that the charge condition of said accumulation-of-electricity means becomes homogeneity more preferably here.

[0010] This invention like claim 2 said equalization means Each of said accumulation-of-electricity means, a connectable capacitor, and a migration means to move a charge to said other at least one accumulation-of-electricity means through said capacitor from said at least one accumulation-of-electricity means, A receipt accumulation-of-electricity means to receive an emission accumulation-of-electricity means to emit a charge for the amount of accumulation of electricity of two or more of said accumulation-of-electricity means to become equal based on each electrical potential difference of said accumulation-of-electricity means, and the emitted charge, A decision means to determine the amount of charge transfer from this emission accumulation-of-electricity means to this receipt accumulation-of-electricity means, and the control means which

controls said migration means so that the amount of charge transfer determined by said decision means moves to said receipt accumulation-of-electricity means from said emission accumulation-of-electricity means can also be had and constituted.

[0011] If it depends on this invention, since the charge between said accumulation-of-electricity means will be moved based on the amount of charge transfer determined by said decision means, schedule-ization of equalization processing is attained and it becomes unnecessary to detect the electrical potential difference of said accumulation-of-electricity means repeatedly.

[0012] moreover, this invention -- claim 3 -- like -- Said decision means The n-th electrical potential difference of N and said emission accumulation-of-electricity means for the number of said emission accumulation-of-electricity means Vns, The m-th electrical potential difference of Vn (t) and said receipt accumulation-of-electricity means for the n-th target electrical potential difference of said emission accumulation-of-electricity means after equalization Vrms, The m-th target electrical potential difference of said receipt accumulation-of-electricity means after equalization Vrm (t), The period with which migration of a charge is carried [electric capacity / of said accumulation-of-electricity means] out to said receipt accumulation-of-electricity means from said emission accumulation-of-electricity means through Cc and said capacitor in the electric capacity of Cb and said capacitor Ti, The multiplier in consideration of a part for the charge loss at the time of moving a charge to said capacitor from said emission accumulation-of-electricity means eta, The multiplier in consideration of a part for the charge loss at the time of moving a charge to said receipt accumulation-of-electricity means from said capacitor lambda, either of the time amount tn and tm which was carried out and was computed from the following two formulas -- it can also be characterized by determining the charge which moves by moving a charge with said migration means between short time amount as said amount of charge transfer.

[0013]

[Equation 5]

[0014] However, [0015]

[Equation 6]

[0016] either of the time amount tn and tm computed by the aforementioned formula when depending on this invention -- since the charge which moves by moving a charge with said migration means between short time amount is determined as said amount of charge transfer, quantity of electricity can be moved more correctly.

[0017] This invention like claim 4 moreover, said equalization means A discharge means to discharge quantity of electricity from said accumulation-of-electricity means, and a discharge accumulation-of-electricity means to discharge quantity of electricity for the amount of accumulation of electricity of two or more of said accumulation-of-electricity

means to become equal based on each electrical potential difference of said accumulation-of-electricity means, A decision means to determine the amount of charge discharge which discharges from this discharge accumulation-of-electricity means, and the control means which controls said discharge means so that quantity of electricity determined by said decision means discharges from said discharge accumulation-of-electricity means can also be had and constituted.

[0018] If it depends on this invention, since quantity of electricity will be discharged from said discharge accumulation-of-electricity means based on quantity of electricity determined with said decision means, schedule-ization of equalization processing is attained and it becomes unnecessary to detect the electrical potential difference of said accumulation-of-electricity means repeatedly.

[0019] Moreover, it can also be characterized by equipping resistance for said discharge means consuming the charge from said accumulation-of-electricity means with the resistance of 100 times or more of the resistance inside said accumulation-of-electricity means like claim 5 in this invention. If it depends on this invention, since the resistance for consuming the charge from said accumulation-of-electricity means will be 100 or more times of the resistance inside said accumulation-of-electricity means, when a current flows for said accumulation-of-electricity means, or when the current which flows in a discharge means can be suppressed a little and a current flows for said accumulation-of-electricity means, equalization processing can be performed correctly.

[0020] Furthermore, said decision means can also be characterized by to determine the amount of charge discharge which discharges between the time amount of either of the time amount tr1 or tr2 which set [the electric capacity of Vr and said accumulation-of-electricity means] the resistance of the VS aforementioned resistor to RBP for the electrical potential difference of Cb and said accumulation-of-electricity means, and computed the target electrical potential difference after equalization from the following two formulas as an amount of charge discharge which discharges from said discharge accumulation-of-electricity means like claim 6.

[0021]

[Equation 7]

[0022]

[Equation 8]

[0023] However, $\alpha = 1/(C_b - R_{BP})$

If it depends on this invention, since the amount of charge discharge which discharges between the time amount of either of the time amount tr1 or tr2 computed by the aforementioned formula will be determined as an amount of charge discharge which discharges from said discharge accumulation-of-electricity means, more exact quantity of electricity can be discharged.

[0024]

[Embodiment of the Invention] With reference to a drawing, the gestalt of operation of this invention is explained below.

[0025] As shown in [gestalt of the 1st operation] drawing 1, the accumulation-of-

electricity equipment 10 concerning the gestalt of this operation is constituted as a group cell 16 by which many rechargeable lithium-ion batteries (henceforth a "dc-battery cel") 16A, 16B, 16C, and 16N as two or more accumulation-of-electricity means were connected to the serial. In addition, although only the four dc-batteries cel is shown in drawing 1 on account of the drawing, the dc-battery cel of a large number which are not illustrated in fact is connected further, and dozens of dc-batteries cel (with the gestalt of this operation, it considers as N individual) is connected to the serial in all. The ammeter 14 as a monitor means for supervising whether the current supply source from accumulation-of-electricity equipment 10 is performed, or principal current is flowing in the circuit 12 is installed in the end of the group cell 16. For the dc-battery cels 16A, 16B, and 16C and the --16N plus terminals 26A, 26C, 26E, and 26M The connectable change-over switch is connected with end 28A of the charge pump capacitor 24. The change-over switch in which connection with other end 28B of the charge pump capacitor 24 is possible is connected to the dc-battery cels 16A, 16B, and 16C and the --16N minus terminals 26B, 26D, 26F, and 26N, and the change connection 22 is constituted. The change connection 22 is connected with the control circuit 20 which controls a change with the charge pump capacitor 24 and each dc-battery cel. In addition, as a switch of the change connection 22, a field-effect transistor (FET), a relay switch, etc. can be used. Moreover, the amplitude-measurement equipments 18A, 18B, and 18C for measuring the electrical potential difference of each dc-battery cel and18N are connected to the dc-battery cels 16A, 16B, and 16C and --16N, and it connects with the control circuit 20 the amplitude-measurement equipments 18A, 18B, and 18C and ..18N.

[0026] Next, the operation in the gestalt of this operation is explained, referring to a drawing.

[0027] With the gestalt of this operation, the charge condition between each dc-battery cel is equated by moving the electrical and electric equipment to the low dc-battery cel of a charge condition through the charge pump capacitor 24 from the high dc-battery cel of a charge condition. That is, actuation of moving the electrical and electric equipment from the high dc-battery cel or dc-battery cel group (henceforth a "corbel cel group") of a charge condition, charging the charge pump capacitor 24, and discharging the charged electrical and electric equipment in the low dc-battery cel or dc-battery cel group (henceforth a "receipt cel group") of a charge condition is repeated. It explains according to the flow chart which shows this charge condition equalization processing to drawing 2.

[0028] First, it judges whether principal current is flowing in the circuit 12 with the ammeter 14 at step 30. When principal current is not flowing, amplitude-measurement total 18A, 18B and 18C, each dc-battery cels 16A, 16B, and 16C measured by18N, and a ..16N electrical potential difference are read at step 32, and it registers with the electrical-potential-difference table which is not illustrated in a control circuit 20. Here, since quantity of electricity and the electrical potential difference in a dc-battery cel are proportional mostly, the electrical potential difference of each dc-battery cel is measured because it is thought that this electrical-potential-difference value shows quantity of electricity in a dc-battery cel, i.e., the charge condition of a dc-battery cel. When principal current is flowing, it stands by until principal current will not flow without performing measurement of said electrical potential difference. It is because that it is necessary to choose the time of principal current not flowing at one's own discretion, and to measure an electrical potential difference cannot measure open circuit voltage exact for

the internal resistance of each dc-battery cel if principal current flows.

[0029] When the electrical potential difference of each dc-battery cel is equated at step 34 based on the amplitude-measurement value of each dc-battery cel, an attainment **** target attainment electrical potential difference is set up. This setup is specifically performed as follows.

[0030] The electrical potential difference (V_n) of each dc-battery cel measured at a certain time presupposes that it is distributed as shown in drawing 8. Since it carries out by moving the electrical and electric equipment to the low dc-battery cel of a charge condition from the high dc-battery cel of a charge condition, equalization of a dc-battery cel will be performed by moving quantity of electricity of the part more than the minimum electrical potential difference (V_{min}). If electric migration effectiveness is performed at 100% at this time (without losing), since it will be thought that the ideal average electrical potential difference (V_{avg}) after equalization becomes equal to what applied the minimum electrical potential difference (V_{min}) to the average electrical potential difference of a part more than the minimum electrical potential difference (V_{min}) of each dc-battery cel, it computes by the following formulas (1-1).

[0031]

[Equation 9]

[0032] Although considered what has many ones of quantity of electricity which carries out rather than quantity of electricity which flows out of the charge pump capacitor 24, and flows out of a cel group by loss in a circuit here, quantity of electricity which flows out of a corbel cel group at this time is expressed as what multiplied quantity of electricity which flows out of the charge pump capacitor 24 by the growth index lambda (> 1). Moreover, a receipt cel group shall also receive the electrical and electric equipment from the charge pump capacitor 24 only at the predetermined effectiveness eta (< 1). Then, correction is added for having computed in consideration of the case of 100% of migration effectiveness (1-1), and the anticipation average electrical potential difference ($V_{realavg}$) after equalization is computed by the following formulas (1-2). In addition, about lambda and eta which are used here, it measures by experiment and sets up beforehand.

[0033]

[Equation 10]

[0034] In this way, let the computed anticipation average electrical potential difference ($V_{realavg}$) be a target attainment electrical potential difference.

[0035] In addition, although the anticipation average electrical potential difference ($V_{realavg}$) was made into the target attainment electrical potential difference in the above-mentioned example, it is also possible for this invention not to be limited to this, and to calculate the average (V_{avg}) of a total dc-battery cel electrical potential difference,

for example, to make this into a target attainment electrical potential difference.

[0036] A corbel cel group is chosen at step 36. The number of the dc-battery cel chosen here is 2, carries out a thing and chooses that from which the sum of the electrical potential difference of the adjoining two dc-batteries cel serves as max as a cel group.

[0037] A receipt cel group is chosen at step 38. The number of the dc-battery cel chosen here is 1, and chooses a thing for that from which the electrical potential difference of a dc-battery cel serves as min as a receipt cel group.

[0038] In addition, the selection number of a corbel cel group and a receipt cel group is not limited to what was mentioned above, and can be made into the number of arbitration. Moreover, it is not limited to the approach which also mentioned above the selection approach of a corbel cel group and a receipt cel group, and the sum of an electrical potential difference can also choose the greatest or minimum thing as a corbel cel group and a receipt cel group, respectively in the adjoining cel group which contains the dc-battery cel of max or the minimum electrical potential difference. Moreover, as a corbel cel group, the minimum electrical-potential-difference cel comparison is carried out in the adjoining cel group containing the dc-battery cel of the maximum electrical potential difference. The cel group which contained the highest thing of an electrical potential difference among these cels is chosen, as a receipt cel group, the maximum electrical-potential-difference cel comparison can be carried out in the adjoining cel group containing the dc-battery cel of the minimum electrical potential difference, and the cel group which contained the lowest thing of an electrical potential difference among these cels can also be chosen.

[0039] When a receipt cel group is charged through the charge pump capacitor 24 at step 40 from a corbel cel group, the attainment anticipation time amount T0 as time amount until it reaches to a target attainment electrical potential difference is set up. This attainment anticipation time amount T0 is computed based on the view expressed below.

[0040] First, it thinks by the case where the dc-battery cel to which the number of 16A, 16B, and a receipt cel group corresponds [the dc-battery cel to which the number of a corbel cel group corresponds by 2] by 1 is 16Ns. The equalization actuation between receipt cel groups connects a corbel cel group and the charge pump capacitor 24 to juxtaposition first as a corbel cel group, the charge pump capacitor 24 is charged, next, connection with the charge pump capacitor 24 is switched to parallel connection with a receipt cel group, and a receipt cel group is charged from the charge pump capacitor 24. It carries out by repeating this equalization actuation, and the electrical potential difference with a receipt cel group is equated as the cel group. If quantity of electricity which moves by the charge pump capacitor 24 at the time of this equalization actuation is set to deltaQ and quantity of electricity of the amount of 16B to deltaQ2 flows out [a dc-battery cel / deltaQ1 from 16A, and a dc-battery cel], it is $\Delta Q = \Delta Q_1 + \Delta Q_2$. (2-1)

It becomes. It is here and is the electrical-potential-difference variation (unit: V) of ΔV_1 :dc-battery cel 16A.

ΔV_2 : Electrical-potential-difference variation of dc-battery cel 16B (unit: V)

C1 : Electric capacity of dc-battery cel 16A (unit: F)

C2 : Electric capacity of dc-battery cel 16B (unit: F) When it carries out, they are $\Delta Q = C_1$ and $\Delta V_1 + C_2 - \Delta V_2$. (2-2)

It becomes. Since the dc-battery cel used here is the thing of the same specification and

there is usually no difference in properties, such as electric capacity and internal resistance, so much, it is $C1=C2=Cb$ and $\Delta V1=\Delta V2$. It carries out.

[0041] Therefore, $\Delta Q=Cb-\Delta V1 + Cb-\Delta V1$ (2-3)

$\Delta V1=\Delta V2=\Delta Q/2$, Cb (2-4)

It becomes.

[0042] Next, electrical-potential-difference change of each cel is mathematized. Here, it is $V1(t)$: Electrical potential difference in the time amount t of dc-battery cel 16A (unit: V)

$V2(t)$: Electrical potential difference in the time amount t of dc-battery cel 16B (unit: V)

$Vr(t)$: Electrical potential difference in the dc-battery cel 16N time amount t (unit: V)

$V1s$: Initial voltage of dc-battery cel 16A (unit: V)

$V2s$: Initial voltage of dc-battery cel 16B (unit: V)

Vrs : Dc-battery cel 16N initial voltage (unit: V)

Cc : Electric capacity of the charge pump capacitor 24 (unit: F)

Ti : Period of a charge-and-discharge cycle (unit: sec) It is [0043] when it carries out.

[Equation 11]

[0044] It becomes.

[0045] Moreover, the dc-battery cel 16N electric capacity Cr which is a receipt cel is also equal to said Cb . $Cr=Cb$ It carries out.

[0046] Here, in practice, by loss in a circuit, since there is more quantity of electricity which flows out of a corbel cel group into the charge pump capacitor 24 than quantity of electricity charged by the charge pump capacitor 24, it expresses to quantity of electricity charged by the charge pump capacitor 24, applying a growth index λ (> 1). On the other hand, a receipt cel group can also receive the electrical and electric equipment only at fixed effectiveness, but since quantity of electricity charged from the charge pump capacitor 24 is smaller than quantity of electricity which flows out of the charge pump capacitor 24, a receipt cel group expresses to quantity of electricity which flows out of the charge pump capacitor 24, applying the reduction multiplier η (< 1).

[0047] Change of each dc-battery cel electrical potential difference at the time of taking into consideration the above growth index λ and reduction multiplier η is [0048].

[Equation 12]

[0049] It becomes.

[0050] If a block diagram expresses this formula, it will become like drawing 9.

[0051] Here, neither the electric capacity Cb of the dc-battery cel 16 nor the electric capacity Cc of the charge pump capacitor 24 is based on elapsed time, but since it is almost fixed, it is solving (2-6), (2-7), and a formula (2-8), and $V1(t)$, $V2(t)$, and time amount change of $Vr(t)$ can be calculated.

[0052] It is [0053], solving using a Laplace transform etc. and using integral initial value as 0.

[Equation 13]

[0054] It is [0055] when it sets.

[Equation 14]

[0056] It becomes.

[0057] Since it is difficult to ask for the time of day t which reaches it when the target electrical potential difference $V_1(t)$ etc. is given from (2-10) with a formula (2-12), it linearizes and approximates by the following approaches so that it may be easy to solve this.

[0058] Here, it is $f(t) = e^{-at} - 1 - a \cdot t$. (2-13) It approximates like. Since order of approximation will estimate highly the time when the value of at is smaller to be oversized from an actual change as shown in drawing 10 if it depends on this approximation approach, as anticipation of change, it will be estimated as an insurance side. Moreover, since it will not be used till the place which an electrical potential difference finally converges in fact but at will use only a small field, it is thought that it is satisfactory practically.

[0059] In addition, it can also be concluded that it was replaced instead of the integral in the block diagram of drawing 9 when this approximation was proportionally made into time amount t .

[0060] It is [0061] when a formula is approximated from using a formula (2-13) (2-12) (2-10).

[Equation 15]

[0062] It is simplified.

[0063] For the time of day which reaches it here when $V_1(t)$, $V_2(t)$, $V_r(t)$, etc. are given, t_1 , t_2 , and t_r are [0064].

[Equation 16]

[0065] ** -- it asks like.

[0066] In addition, although the number of carrying-out cels thought in the above-mentioned example by the case where two pieces and the number of reception cels are one piece, when the number of carrying-out cels is [N individual and the number of reception cels] M pieces, a formula (2-14) and (2-16) (2-17) a formula (2-19) can be expressed as follows.

[0067]

[Equation 17]

[0068]

[Equation 18]

[0069] Therefore, at this step 40, any of (2-22) and (2-23) or the shorter one is set up as attainment anticipation time amount T0.

[0070] At step 42, equalization actuation shown in drawing 3 is performed. It is step 52, and that the corbel cel group and the charge pump capacitor 24 of the dc-battery cels 16A and 16B by which the sum of an electrical potential difference serves as max should be connected to juxtaposition, specifically, the change connection 22 is controlled so that terminal 26A of a dc-battery cel, terminal 28A of the charge pump capacitor 24, and terminal 26D of a dc-battery cel and terminal 28B of the charge pump capacitor 24 are connected. Then, although charge is performed to the charge pump capacitor 24 from a corbel cel group, it judges whether quantity of electricity of a capacitive component was stored in the charge pump capacitor 24 at step 54. If quantity of electricity of a capacitive component is stored in the charge pump capacitor 24, connection between a corbel cel group and the charge pump capacitor 24 will be canceled, and a receipt cel group and the charge pump capacitor 24 will be connected to juxtaposition at step 56. Here, terminal 28A of the terminal 26M and the charge pump capacitor 24 of a dc-battery cel controls the change connection 22 so that 26 Ns of terminals of a dc-battery cel and terminal 28B of the charge pump capacitor 24 are connected. Then, charge is performed to dc-battery cel 16N which is a receipt cel group from the charge pump capacitor 24. When it judges whether the charge to a receipt cel group was completed at step 58 and the charge to a

receipt cel group is completed, it progresses to step 44 of drawing 2. Here, one equalization actuation shown in drawing 3 is 1 cycle of charge and discharge, and the time amount which this 1 cycle takes corresponds to the period T_i of the above-mentioned 1 charge-and-discharge cycle.

[0071] It judges whether the attainment anticipation time amount T_0 was reached at step 44 of drawing 2. Since a corbel cel group and a receipt cel group have not reached the set-up target electrical potential difference when the attainment anticipation time amount T_0 is not reached, equalization actuation of step 42 is repeated. When the attainment anticipation time amount T_0 is reached, based on the attainment anticipation time amount T_0 , it carries out at step 46, the electrical-potential-difference value after equalization actuation of dc-battery cel [which were cel groups]A [16] and 16B, and dc-battery cel which was receipt cel group 16N is computed, and the electrical-potential-difference value of said electrical-potential-difference table is replaced at step 48. Here, the electrical potential difference of the dc-battery cel to which the electrical-potential-difference value reached the target electrical potential difference is deleted from said electrical-potential-difference table. At step 50, it judges whether the following cel group is equated. Here, it judges as follows whether the following cel group is equated. That is, since the dc-battery cel which reached the target electrical potential difference one by one is deleted from the electrical-potential-difference table, when one of all the dc-battery cels of a corbel cel group or a receipt cel group are deleted, equalization of the following cel group is not performed but this processing is ended. When it carries out to an electrical-potential-difference table and the both sides of a cel group and a receipt cel group remain, in order to perform the next equalization processing, it returns to step 36 and the following processings are repeated.

[0072] Since the electrical potential difference of a dc-battery cel will be measured while principal current is not flowing if it depends on the gestalt of this operation, the more exact open circuit voltage of a dc-battery cel can be measured. Therefore, based on this exact open circuit voltage, a more suitable corbel cel group and a receipt cel group can be chosen.

[0073] Moreover, since the electrical potential difference of a dc-battery cel is measured, a target electrical potential difference, attainment anticipation time amount, and the dc-battery cel electrical potential difference after electrical-potential-difference equalization are computed based on this electrical potential difference and equalization processing is schedule-ized as mentioned above while principal current is not flowing, it is not necessary to measure a dc-battery cel electrical potential difference for every 1 equalization cycle, and does not ask whether principal current is flowing, but when required, a dc-battery cel electrical potential difference can be equated. Furthermore, since calculation of attainment anticipation time amount is performed using the approach of making it approximate after taking into consideration electrical-potential-difference change of the dc-battery cel electrical potential difference under electrical-potential-difference equalization actuation, it can perform more exact electrical-potential-difference equalization processing.

[0074] About the gestalt of [gestalt of the 2nd operation] the 2nd operation, if attached to the same part as the gestalt of the 1st operation, explanation is omitted.

[0075] The operation concerning the gestalt of this operation is explained referring to drawing 4 and drawing 5.

[0076] The cel electrical-potential-difference read in routine shown in drawing 5 is started to fixed time amount (every [for example,] 10 minutes). At step 30 and step 32, the electrical potential difference of each dc-battery cel is saved on an electrical-potential-difference table like the gestalt of the 1st operation. At step 70, the electrical-potential-difference data flag which shows that said electrical-potential-difference table was updated is set, and this cel electrical-potential-difference read in routine is ended. Based on each dc-battery cel electrical-potential-difference data saved here, electrical-potential-difference equalization processing shown in drawing 4 is performed.

[0077] At step 60, the electrical-potential-difference data saved on said electrical-potential-difference table are read. At step 62, an electrical-potential-difference data flag [finishing / a set] is reset. Step 48 is performed like the gestalt of the 1st operation from step 34. At step 64, it judges whether the electrical-potential-difference data flag is set. Here, when the electrical-potential-difference data flag is set, the cel electrical potential difference is newly read during equalization actuation. Since most time amount would be taken before equalization processing of all cel electrical potential differences is completed, each dc-battery cel electrical potential difference might be replaced with the time of measuring at the beginning by change of temperature distribution in the meantime etc. Then, that equalization processing should be continued based on the electrical-potential-difference data updated for every fixed time amount, when the electrical-potential-difference data flag is set, it returns to step 60, read in of an electrical-potential-difference table is performed again, and the following processings are repeated. Since the data of an electrical-potential-difference table are not updated when the electrical-potential-difference data flag is not set, it returns to step 36 like the gestalt of the 1st operation, and the following processings are repeated.

[0078] If it depends on the gestalt of this operation, since each dc-battery cel electrical potential difference will be measured for every fixed time amount under equalization processing, electrical-potential-difference data will be updated and schedule-ization of electrical-potential-difference equalization processing will be attained, more exact electrical-potential-difference equalization processing can be performed.

[0079] Explanation is omitted if attached to the 1st and the same part as the gestalt of the 2nd operation also about the gestalt of [gestalt of the 3rd operation] the 2nd operation.

[0080] The operation concerning the gestalt of this operation is explained referring to drawing 6 and drawing 7.

[0081] Step 34 is performed like the gestalt of the 1st operation of the above-mentioned from step 30 of the electrical-potential-difference equalization processing shown in drawing 6. At step 80, the corbel and receipt cel selection processing shown in drawing 7 are performed.

[0082] At step 82, the dc-battery cel of an electrical potential difference higher than the target electrical potential difference Vobj is chosen, and it is from a cel with a large electrical potential difference with ****1k and ****21..... to order. Ranking attachment is carried out. At step 84, the dc-battery cel of an electrical potential difference lower than the target electrical potential difference Vobj is chosen, and ranking attachment is carried out with VN1i and VN2j.... from a cel with a small electrical potential difference at order. Here, k, l,i, and j are either of the cel numbers numbered sequentially from the edge based on the location of a dc-battery cel, sequentially from the cel 1 located in an end, N dc-battery cels are prepared and Cel N is located in the other end. At step 86, the dc-

battery cel **** 1 with the highest cel electrical potential difference judges whether it is $k=N$, it is the cel, $k= 1$ [i.e.,], which are located in an edge or. When the dc-battery cel **** 1 is not a cel located in an edge, it is electrical-potential-difference V_{k+1} of the cel of the both ends of this cel. And V_{k-1} judges whether it is larger than the target electrical potential difference V_{obj} . Cel $k+1$ And electrical-potential-difference V_{k+1} of $k-1$ And when V_{k-1} is larger than the target electrical potential difference V_{obj} , it judges whether it is $V_{k+1} > V_{k-1}$ at step 90. In the case of $V_{k+1} > V_{k-1}$, it is with $k+1$. Since sum $V_{k+1}+V_k$ of the electrical potential difference of a cel group with k is larger than sum $V_{k-1}+V_k$ of the electrical potential difference of the cel group of k and $k-1$, it reaches $k+1$ as a corbel cel at step 98. k is chosen. When it is not $V_{k+1} > V_{k-1}$, it is with $k-1$. Since sum $V_{k-1}+V_k$ of the electrical potential difference of a cel group with k is larger than sum $V_{k+1}+V_k$ of the electrical potential difference of the cel group of $k+1$ and k , it reaches $k-1$ as a corbel cel at step 100. k is chosen. At step 88, it is a cel $k+1$ and electrical-potential-difference V_{k+1} of $k-1$. And when at least one side of V_{k-1} is smaller than the target electrical potential difference V_{obj} , it judges whether electrical-potential-difference V_{k+1} of a cel $k+1$ is larger than the target electrical potential difference V_{obj} at step 94. When electrical-potential-difference V_{k+1} of a cel $k+1$ is larger than the target electrical potential difference V_{obj} , it carries out at the above-mentioned step 98, and reaches $k+1$ as a cel. k is chosen. When electrical-potential-difference V_{k+1} of a cel $k+1$ is smaller than the target electrical potential difference V_{obj} , it judges whether electrical-potential-difference V_{k-1} of a cel $k-1$ is larger than the target electrical potential difference V_{obj} at step 96. When electrical-potential-difference V_{k-1} of a cel $k-1$ is larger than the target electrical potential difference V_{obj} , it reaches $k-1$ as a corbel cel at the above-mentioned step 100. k is chosen. When electrical-potential-difference V_{k-1} of a cel $k-1$ is smaller than the target electrical potential difference V_{obj} , it is a cel $k+1$. And electrical-potential-difference V_{k+1} of $k-1$ And since the both sides of V_{k-1} are smaller than the target electrical potential difference V_{obj} , it does not choose as a corbel cel, but at step 102, Cel k is carried out and it chooses as a cel. Moreover, when the cel **** 1 of a maximum voltage is located in the end of a group battery at step 86 (i.e., when it is judged as $k= 1$ or $k=N$), Cel k at step 92 It judges whether it is in the location of $k= 1$. Cel k Since the cel of $k= k-1$ does not exist when it is $k= 1$, it progresses to step 94 mentioned above, and the following processings are performed. Cel k Since it is $k=N$ and the cel of $k= k+1$ does not exist in not being $k= 1$, it progresses to step 96 mentioned above, and the following processings are performed. After carrying out as mentioned above and determining a cel group, the lowest dc-battery cel of a cel electrical potential difference is chosen as a receipt cel at step 104. 44 or less step processes like the gestalt of the 1st operation, and ends this processing.

[0083] In the case of selection of a corbel cel, if it depends on the gestalt of this operation, since it is made not to choose the dc-battery cel with an electrical potential difference lower than the target electrical potential difference V_{obj} , the corbel cel group of a high electrical potential difference can be constituted more appropriately, as a result, an electrical-potential-difference difference with a receipt cel group also becomes large as a corbel cel group, and equalization processing of an electrical potential difference can be performed more quickly.

[0084] Also about the gestalt of [gestalt of the 4th operation] the 4th operation, if attached to the same part as the gestalt of the above-mentioned operation, the same

notation is attached and explanation is omitted.

[0085] As shown in drawing 11, they are the dc-battery cels 16A, 16B, and 16C.... The circuit (henceforth a "discharge circuit") where the resistor 78 and the switch 76 were connected to the serial at 16Ns, respectively is connected to juxtaposition. This discharge circuit 74 turns on a switch 76, and equates the charge condition of each dc-battery cel by making the charge charge of each dc-battery cel discharge through a resistor 78. Control circuits 20 are Switches 76A, 76B, and 76C.... It connects with 76 Ns and turning on and off of each switch is controlled. The charge pump capacitor 24 installed in the accumulation-of-electricity equipment concerning the gestalt of the above-mentioned operation and the change connection 22 do not have.

[0086] Drawing 12 (A) shows the discharge circuit 74 for having connected with one dc-battery cel 16A. At the time of ON of switch 76A, it is said that a current flows in the direction of W in the discharge circuit 74 (it is a "bypass current" below about this current). Internal resistance R_{in} exists in the interior of dc-battery cel 16A, and the interior of dc-battery cel 16A can be shown like drawing 12 (B).

[0087] Resistors 78A, 78B, and 78C installed in each discharge circuit 74 here Let the resistance of 78 Ns be a sufficiently large value as compared with the dc-battery cels 16A, 16B, and 16C and ..16N internal resistance. Usually, although it is desirable to consider as about 1000 to 10000 times, it may be necessary to be about 100 times also at the lowest.

[0088] Next, the operation in the gestalt of this operation is explained according to the flow chart shown in drawing 14.

[0089] Step 34 processes like the gestalt of the above-mentioned operation from step 30. At step 110, attainment anticipation time amount $tr-tn$ to a target electrical potential difference is set up for every cel. Specifically based on the following views, it computes.

[0090] First, the bypass current IBP when switch 76A is turned on in the discharge circuit 74 shown in drawing 12 (A) sets $Vb(t)$ and discharge circuit resistance to R_{BP} for the dc-battery cel electrical potential difference in time amount t , and is [0091].

[Equation 19]

[0092] It becomes.

[0093] A changed part (ΔQ) from the initial capacity (Q_s) of quantity of electricity (Q_b) of dc-battery cel 16A by the bypass current IBP is [0094].

[Equation 20]

[0095] It becomes.

[0096] Moreover, for the capacity C_b of dc-battery cel 16A, it is not based on change of the dc-battery cel electrical potential difference V_b and the initial voltage V_s of dc-battery cel 16A, but thinks as fixed, and quantity of electricity change part ΔQ of dc-battery cel 16A is $\Delta Q = C_b \cdot (V_s - V_b(t))$ by change of the dc-battery cel electrical potential difference V_b . (3-3) It becomes.

[0097] Usually, quantity of electricity Q and the dc-battery cel electrical potential difference of a dc-battery cel (release electrical potential difference) In the case of a lithium ion battery, although V changes like drawing 13, as long as it becomes between

narrow range (delta V1, delta V2 of drawing 13), it may conclude that the relation is proportional mostly. Moreover, the value of C_b may be partly prepared by the field of V or Q .

[0098] It is [0099] from (3-1), (3-2), and (3-3).

[Equation 21]

[0100] It is [0101], when it sets with $1/(C_b \cdot RBP) = \alpha$ and a Laplace transform, however integral initial value set a formula (3-4) to 0.

[Equation 22]

[0102] (3-5) It is [0103] when it sets with $V_s = V_s/s$ from a formula again (V_s time as many unit-step input as this).

[Equation 23]

[0104] *****. The reverse Laplace transform of the formula (3-6) is carried out. $V_b(t) = V_s \cdot e^{-\alpha \cdot t}$ (3-7) It is obtained, thus change of the dc-battery cel electrical potential difference of t -hour after can be predicted.

[0105] The time amount t_r required for reaching it when the target electrical potential difference V_r is given is [0106] from a formula (3-7).

[Equation 24]

[0107] It is obtained by carrying out.

[0108] The time amount t_r taken to reach there when $e^{-\alpha \cdot t} = 1 - \alpha \cdot t$ was approximated in (3-7) and the target electrical potential difference V_{br} is given here is [0109].

[Equation 25]

[0110] It is come out and given and can predict by the easy formula which does not use a logarithm. If only this time amount turns on a discharge circuit, it can bring to a predetermined target electrical potential difference at the beginning.

[0111] Here, α is small (C_b is size and 78A is size), or if t is small, since it will be high as order of approximation, it needs to be careful to approximate.

[0112] The time amount (attainment anticipation time amount) t_{r1-trn} for every dc-battery cel required in order to carry out time of concentration to the target electrical potential difference V_r by the formula (3-9) as mentioned above can be set up. In addition, time amount computed by the formula (3-8) before approximating can also be made into the attainment anticipation time amount t_{r1-trn} .

[0113] Switches 76A, 76B, and 76C formed in the discharge circuit 74 of each dc-battery cel at step 112 Only the attainment anticipation time amount which computed 76 Ns

as mentioned above is turned on. When the switch of a discharge circuit is turned on, Bayh bus current flows in a discharge circuit, and they are Resistors 78A, 78B, and 78C.... Discharge is started from 78Ns. When only said attainment anticipation time amount performs this discharge, the electrical potential difference of each dc-battery cel turns into a target electrical potential difference, and is equated.

[0114] Here, since a dc-battery cel electrical potential difference is changed when principal current flows, and principal current flows, the effect is taken into consideration.

[0115] As shown in drawing 12 (B), when it sets cell internal resistance to RIN and principal current is set to IM, the current part IMBP which flows in the discharge circuit 74 among principal current IM is [0116] at this time.

[Equation 26]

[0117] It becomes. Then, even if the cell internal resistance RIN is small enough, or the current part IMBP which will flow in the discharge circuit 74 if the resistance RBP of resistor 78A is large enough is small enough and principal current IM flows, the bypass current IBP will be affected.

[0118] Usually, although the current part IMBP which flows in the discharge circuit 74 will be set to about (1/1000 of IM) 5mA when principal current IM is 50A if the resistance RBP of resistor 78A is chosen as about 30-50ohms since the cell internal resistance RIN is about 3-5mohm Since the bypass current IBP is 120-72mA in cell voltage 3.6V from the first, 5mA of the current part IMBP which flows in the discharge circuit 74 becomes about 7%. moreover, in the case of the hybrid car, especially principal current IM is always flowing in the same direction -- ***** -- average -- plus and minus -- since it is considered same extent, in practice, the effect on the current part IMBP which flows in the discharge circuit 74 also works for both double sign, and is considered to be a still smaller thing. Therefore, it turns out that a changed part by principal current having flowed also by this case does not need to take into consideration. In addition, as for the resistance RBP of a resistor 78, it is desirable for it to be necessary to consider as about 100 times of the cell internal resistance RIN also at the lowest, and to usually consider as about 1000 to 10000 times.

[0119] At step 114, it judges whether attainment anticipation time amount passed about all dc-battery cels. This processing is ended when it stands by until this attainment anticipation time amount passed when attainment anticipation time amount has passed about no dc-battery cels, and attainment anticipation time amount passes.

[0120] If it depends on the gestalt of this operation, it can consider as a simpler circuit (discharge circuit), and an electrical potential difference can be equated by low cost. Moreover, while there is little effect which does to the current value which flows all over a discharge circuit and being able to perform electrical-potential-difference equalization processing irrespective of whether principal current is flowing even if principal current flows since the resistance of the resistor of a discharge circuit was made into the sufficiently large value as compared with the resistance inside a dc-battery cel, the absolute value of the current which flows the inside of a discharge circuit, and the effectiveness that become small and an exoergic cure becomes unnecessary can be acquired. Furthermore, if it depends on the gestalt of this operation, since it will be taken into consideration that a dc-battery cel electrical potential difference changes, and a

bypass current value also changes during discharge and calculation of the time amount discharging, the attainment anticipation time amount, i.e., the resistor, to a target electrical potential difference, will be performed, a more exact amount can be discharged and it can discharge more appropriately.

[0121]

[Effect of the Invention] Since said accumulation-of-electricity means is equated based on each electrical potential difference of said accumulation-of-electricity means detected while the current was not flowing from said accumulation-of-electricity means, i.e., the exact electrical potential difference in the condition that said accumulation-of-electricity means is not influenced with the internal resistance etc., according to this invention as explained above, it has the advantageous effectiveness that suitable equalization can be performed correctly.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the circuit diagram of the 1st, the 2nd, and the accumulation-of-electricity equipment in the gestalt of the 3rd operation.

[Drawing 2] It is the flow chart which shows the electrical-potential-difference equalization processing concerning the gestalt of the 1st operation.

[Drawing 3] It is the flow chart of the electrical-potential-difference equalization processing concerning the gestalt of the 1st operation shown in part.

[Drawing 4] It is the flow chart which shows the electrical-potential-difference equalization processing concerning the gestalt of the 2nd operation.

[Drawing 5] It is the flow chart which shows the cel electrical-potential-difference read in processing concerning the gestalt of the 2nd operation.

[Drawing 6] It is the flow chart which shows the electrical-potential-difference equalization processing concerning the gestalt of the 3rd operation.

[Drawing 7] It is the flow chart of the electrical-potential-difference equalization processing concerning the gestalt of the 3rd operation shown in part.

[Drawing 8] It is the graph which shows the relation between distribution of a cel electrical potential difference, and the average electrical potential difference after electrical-potential-difference equalization.

[Drawing 9] It is the block diagram showing the cel electrical-potential-difference change under equalization actuation.

[Drawing 10] $f(t) = e^{-at}$ $f(t) = 1 - at$ It is the graph which shows relation.

[Drawing 11] It is the circuit diagram of the accumulation-of-electricity equipment concerning the gestalt of the 4th operation.

[Drawing 12] It is the discharge circuit diagram of 1 dc-battery cel concerning the gestalt of the 4th operation.

[Drawing 13] It is the graph which shows the cell voltage in the gestalt of the 4th operation, and the relation of cell *****.

[Drawing 14] It is the flow chart which shows the electrical-potential-difference equalization processing concerning the gestalt of the 4th operation.

[Description of Notations]

10 Accumulation-of-Electricity Equipment

14 Ammeter (Detection Means)

16A, 16B, 16C 16Ns Dc-battery cel (accumulation-of-electricity means)

18A, 18B, 18C 18Ns Amplitude-measurement machine (electrical-potential-difference detection means)

20 Control Circuit (Control Means)

22 Change Connection

24 Capacitor

76A, 76B, 76C 76Ns Switch

78A, 78B, 78C 78Ns Resistor (discharge means)

DRAWINGS

[Drawing 1]

[Drawing 2]

[Drawing 3]

[Drawing 5]

[Drawing 7]

[Drawing 4]

[Drawing 6]

[Drawing 8]

[Drawing 11]

[Drawing 9]

[Drawing 10]

[Drawing 12]

[Drawing 13]

[Drawing 14]